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Stock Assessment of Dolly Varden on the Anchor River, Alaska, during 1991

by

L. L. Larson

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES (Continued)

LIST OF FIGURES

LIST OF APPENDICES

ABSTRACT

During the period 2 July to 15 August 1991, abundance, composition, and selected fishery statistics were estimated for Dolly Varden *Salvelinus malma* (Walbaum) on the Anchor River. A total of 18,002 fish were counted through a weir and an estimated 1,520 fish were harvested primarily in the lower 1.5 km of the Anchor River. An additional 3,000 Dolly Varden were estimated to have passed upstream of the weir site during a 3-day period when the weir was inoperable. The total immigration of approximately 21,500 Dolly Varden represents the largest Dolly Varden return to the Anchor River since 1987 when the weir study was first implemented.

A reduction in the Dolly Varden daily bag and possession limit from five to two went into effect during 1991. The harvest was reduced 30% from 1990 levels even with a doubling of run strength from one year to the next. Anglers were selective towards harvesting fish greater than 300 mm in fork length regardless of age or sexual maturity.

Estimates of annual survival supported the concept that complete annual homing to the Anchor River only occurs for age classes fully recruited to the spawning population. Instantaneous rates of natural mortality (M) were relatively high and ranged from 0.309 to 3.425 for ages 5 to 8. Instantaneous rates of fishing mortality (F) were generally an order of magnitude lower than estimates of M although annual exploitation by the Anchor River fishery ranged up to 0.661 for fully recruited age classes to the spawning population.

KEY WORDS: Anchor River, Kenai Peninsula, anadromous, Dolly Varden, creel survey, harvest, effort, weir, age composition, sex composition, maturity index, *Salvelinus malma*, population dynamics, mortality, survival.

INTRODUCTION

The Anchor River on the lower Kenai Peninsula (Figure 1) supports recreational fishing for chinook salmon *Oncorhynchus tshawytscha*, coho salmon *O. kisutch*, pink salmon *O. gorbuscha*, Dolly Varden *Salvelinus malma*, and anadromous (steelhead trout) and resident rainbow trout *O. mykiss*. The downstream section of this stream is crossed by the Sterling Highway making it easily accessible to the fishing public. Much of the river frontage along the lower 3 km of this stream is publicly owned, providing ample camping and parking areas. Due to the relatively small size of this stream, all fishing is conducted from the bank. The Anchor River has provided an average of 31,748 recreational fishing days (angler-days) annually from 1977 through 1990 (Mills 1979-1991). The fisheries targeting chinook salmon, coho salmon, steelhead trout, and Dolly Varden are of major importance to recreational anglers on the Anchor River, whereas the fisheries targeting resident rainbow trout and pink salmon are of lesser importance.

The recreational fishery for Dolly Varden in the Anchor River is one of the largest in Alaska and is of particular concern to resource managers. During the period 1977 to 1983, the harvest from this fishery averaged nearly 15,000 fish annually (Mills 1979-1984). In 1984, regulations for this fishery became more restrictive, bag and possession limits were reduced from ten to five fish, and the use of bait was prohibited after 16 September. While these regulations were in effect, the harvest of Dolly Varden averaged approximately 3,700 fish (Table 1). Although a marked decline was observed in the harvest of Dolly Varden after initiation of the new regulations, concerns were expressed that the decline may reflect a depressed population. During 1990, the use of bait was prohibited during the period 15 August through 31 December (ADF&G 1990). In 1991, regulations further restricted the daily bag limit from five to two fish and the use of bait was prohibited during the period 1 September through 31 December (ADF&G 1991).

The reduction in bag limit from five to two was implemented on Anchor River, Deep Creek, Stariski Creek, and Ninilchik River to protect the Dolly Varden spawning stock of the lower Kenai Peninsula. There was evidence from the Statewide Harvest Survey that harvests of Dolly Varden in the late 70s and early 80s exceeded recent levels of total abundance on these streams. A weir was established on the Anchor River in 1987, providing estimates of total abundance of the Dolly Varden immigration. The number of spawners in the immigration was also estimated at the weir. Since 1987, the spawner exploitation rate in the sport fishery ranged from 17% to 32% and averaged 25% (Larson 1990). Catch rates from 1987 through 1989 averaged 57% of the total abundance and were highest (70%) in 1988. Thus, in addition to removing up to one-third of the spawners each year, the sport fishery had a very large released component and it was suspected that mortality among these fish was high. The 70% catch rate and 32% spawner exploitation rate in 1988 occurred predominantly on the 300 mm to 349 mm length cohort. That same cohort, 1 year later, was depressed to less than half the expected abundance. These data, along with the continuing decline in abundance at the weir, suggested that a reduction in exploitation was necessary to protect the major lower Kenai Peninsula spawning stocks.

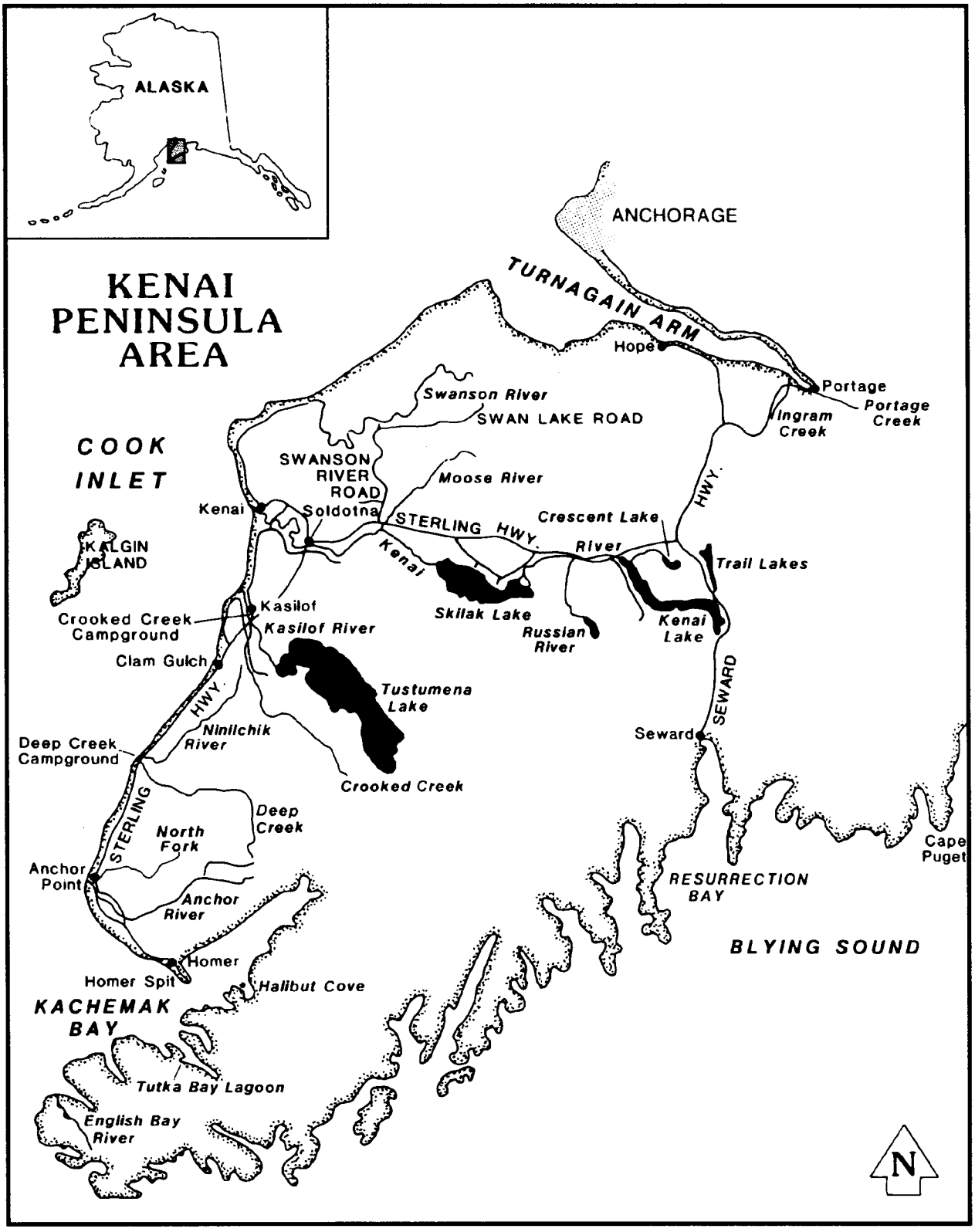

Figure 1. Map of Kenai Peninsula.

Table 1. Historical catch and harvest data from the Anchor River Dolly Varden sport fishery, 1977-1991.

	Creel Survey		Statewide Harvest Survey
Year	Catch	Harvest	Harvest
1977			9,222
1978			17,357
1979			21,364
1980			10,948
1981			15,271
1982			10,375
1983			17,277
1984			5,560
1985			7,720
1986			3,910
1987	9,414	2,653	2,735
1988	11,992	2,915	2,746
1989	5,605	1,615	1,476
1990	5,391	2,124[a]	2,821
1991	5,995	1,520[b]	

[a] Fishing for Dolly Varden was closed by emergency order after 7 August 1990.

[b] The daily Dolly Varden bag limit was reduced from five to two beginning in 1991.

The 1991 immigration of Anchor River Dolly Varden increased in size for the first time since a weir was established in 1987. Although a total fish count was not achieved, due to portions of the rigid weir being removed during a 3-day high water period, more fish were counted from 4 July through 15 August than had previously been counted at the weir during this time period. The reason(s) for this population increase is not completely understood and additional studies are required.

This study will provide additional information necessary to manage the Dolly Varden spawning stock. The acquisition of basic Anchor River and non-Anchor River population data such as a total census, harvest, length and age composition, relative maturity, and exploitation and contribution rates to the fishery will provide the means to estimate key population parameters necessary for estimating maximum sustained yield (MSY). Since this fishery is complicated by concurrent fisheries for other species, it is also necessary to acquire specific fisheries information on all species so that additional regulatory measures (if necessary) can be effectively implemented.

Information pertaining to Dolly Varden has been presented by Allin (1954, 1957), Balland (1985, 1986), Nelson et al. (1987), Larson et al. (1988), Larson and Balland (1989), Larson (1990, 1991), Wallis and Balland (1981-1984) and Wallis and Hammarstrom (1979-1982). Harvest and effort estimates have been reported by Mills (1979-1991).

METHODS

Study Design

This is the sixth year of what is envisioned to be a long-term study of lower Kenai Peninsula Dolly Varden populations. Dynamics of anadromous southern form Dolly Varden (Behnke 1980) populations are complex because they typically exhibit complicated migratory and homing patterns involving lake and non-lake watersheds (Armstrong 1965 and 1984; Sonnichsen 1990). Dolly Varden typically overwinter in lakes, but may spawn in either a lake system or a non-lake system. The Anchor River, which is the major study stream, is a non-lake system.

Sport Fishery

The creel survey area was reduced from previous years to include only those waters downstream of the Old Sterling Highway bridge located at Anchor Point (Figure 2). Approximately 95% of the Dolly Varden fishing occurs downstream of this bridge (Larson 1991). By reducing the creel area and increasing the number of completed angler interviews in the most heavily utilized fishing area, the relative precision of the creel estimates were expected to improve.

A roving creel survey (Neuhold and Lu 1957) was conducted on the Anchor River from 2 July to 2 September 1991. The creel survey provided estimates of harvest and effort by recreational anglers. The creel survey used a stratified systematic sample design with two daily strata. Days represented the first stage and angler counts and angler interviews represented the second stage of a two-stage sample design. Within the day, effort was estimated using angler counts and HPUE (harvest per unit effort) and CPUE (catch per

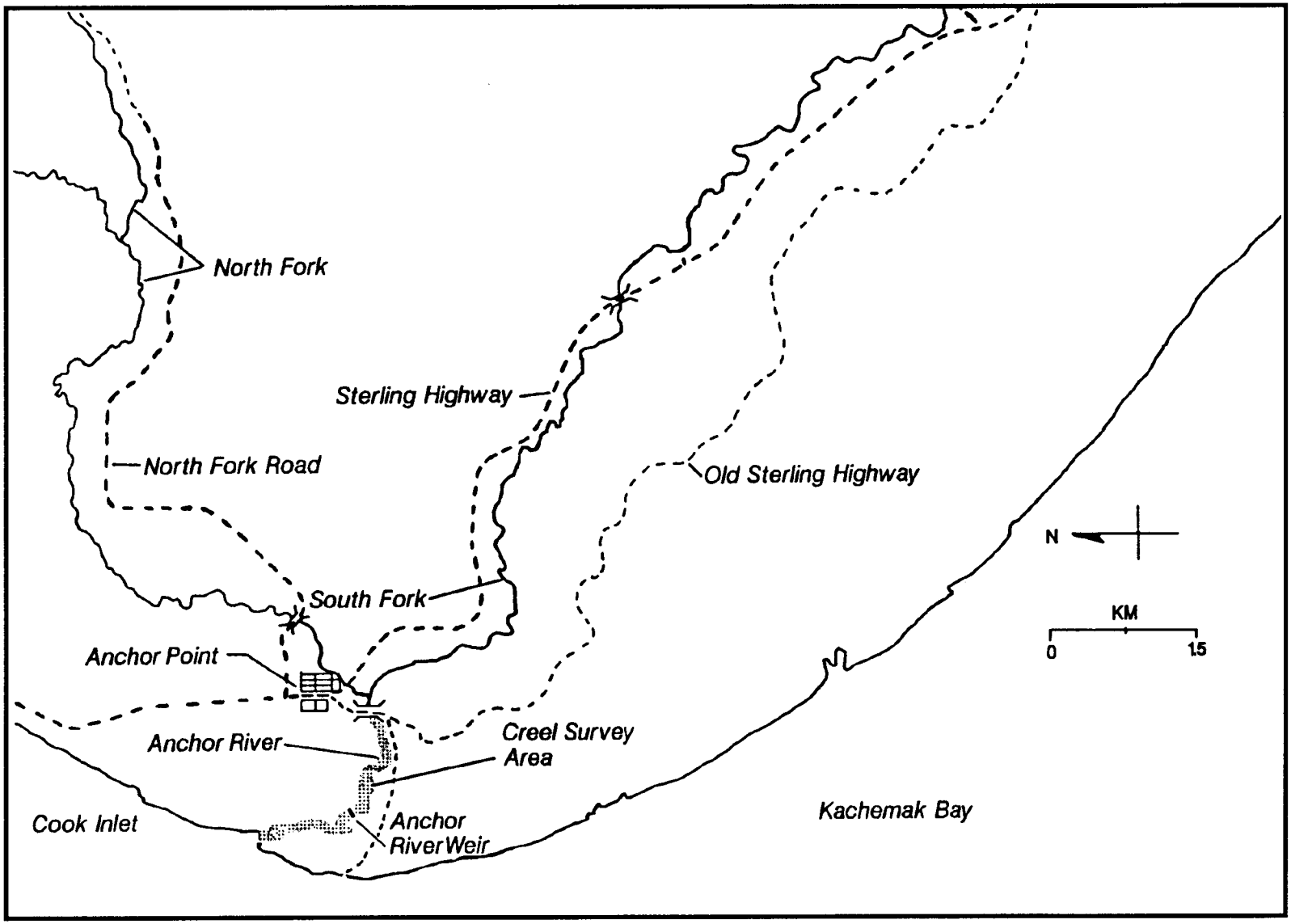

Figure 2. Map of the Anchor River.

unit of effort) were estimated from angler interviews. Past observations indicated that angler effort between the hours of 2200 to 0600 hours was insignificant so the fishing day was defined as 16 hours in duration (0600-2200 hours) and was stratified into two daily time strata (referred to as periods): (A) 0600-1359 hours and (B) 1400-2159 hours. Thus, there were four strata for which total catch, harvest, and effort were estimated.

Sample days were selected systematically. The A period was sampled every fourth day and the B period every third day. This resulted in 16 samples taken in period A and 21 in period B during July and August combined. Once a period was chosen, the entire 8-hour period was sampled. Three counts were made systematically within each period, such that the first count time was chosen randomly from the first four 40-minute time units within the first 160-minute time block (3 X 160 minutes = one 8-hour period) and the next two counts were placed at 2 hour and 40 minute intervals. Interviews were collected over the remainder of each 160-minute time block for a total of 6 hours in each sample period. This survey design was expected to provide estimates of effort, harvest, and catch within 30% of the true value 95% of the time.

Only anglers actively engaged in fishing during the count hour were counted. Angler counts were recorded separately for the area downstream and upstream of the weir during weir operations. The interview recorded hours fished and fish caught and released separately for the two areas. Only completed interviews were used to estimate mean CPUE and HPUE. Completed-trip anglers were surveyed for demographic information, terminal gear selection, target species, and fishing location. The equations used to obtain catch and harvest estimates are located in Appendix A.

The creel technician collected a random sample of harvested Dolly Varden for sex, age, relative maturity (females only), and fork length. These data were used to estimate age composition, sex composition, length frequency, and length-at-age. Age and sex composition were estimated as simple proportions. Letting P_h equal the estimated proportion of age or sex group h, the variance of P_h was estimated by (Scheaffer et al. 1979):

$$\hat{V}(P_h) = \hat{P}_h(1-\hat{P}_h)/(n_T-1) \quad (1)$$

where n_T is the total number of samples. Length-frequency was estimated in 50 mm increments.

Anchor River Weir

A weir was installed approximately 1.5 km upstream from the saltwater terminus of the Anchor River (Figure 2). The weir structure was constructed of both rigid and floating weir panels. The rigid panel pickets were 1.25 cm diameter solid aluminum rods placed in an aluminum channel framework having a 1.25 cm gap between pickets. Channel frames were 3.6 m long by 1.05 m high. The aluminum frames rested against wooden tripods spaced approximately 3.0 m apart. The floating panel pickets were 2.5 cm diameter hollow PVC tubing, capped at each end to provide buoyancy, having a 1.5 cm gap between pickets. Each panel, 4.5 m long, was anchored at one end to a cable and railroad track hinge system laid perpendicular to the stream flow and along the stream

bottom. A resistance board fastened to the downstream end of each panel provided the necessary lift to the panels as river water depth varied. Traps were installed to capture both upstream and downstream migrating fish.

All fish passing through the upstream and downstream traps were counted by species and examined for tags and evidence of angler hook wounds. All tagged Dolly Varden were measured to the nearest millimeter from tip-of-snout to fork-of-tail (fork length). Dolly Varden that were difficult to handle were anesthetized in a CO_2 water bath prior to being measured, otherwise a tagging cradle was used (Hammarstrom and Larson 1985).

Biological Sampling

Approximately 1% of the Dolly Varden immigration was sampled for age (otolith removal), sex, relative maturity (female gonad development), and weight. Approximately 4% of the fish were sampled for length. Relative maturity of each female was determined by using the criteria described by Blackett (1968).

Weir samples were chosen by randomly selecting a trap load and sampling all fish from that trap load. Mortalities at the weir and samples from the sport harvest were sampled for age, sex, relative maturity, and length. Mortalities were also examined for injuries. Age was estimated from otoliths. Sex determination was based on examination of gonads. Fork length was measured to the nearest millimeter.

Stock Structure and Dynamic Rates

Historical length frequency information was used to estimate the sexual maturity component of immigrating Dolly Varden for each year of weir operation (1987-1991). The source of the length frequency data varied between years as sampling methodology changed. During 1987 and 1988, length data were acquired from tagging studies, and during the period 1989 through 1991, length data were acquired from the random sampling schedule described in the biological sampling section of this report.

The sexual maturity components consisted of three categories: nonspawners, potential spawners, and spawners. The length range encompassing each category was based on historical Anchor River female maturity length frequency data (1989-1991). Dolly Varden less than 300 mm fork length were considered nonspawners; fish 300-349 mm, potential spawners; and fish greater than 349 mm, spawners.

Stock structure of each sexual maturity (nonspawner, potential spawner, spawner) and age component were estimated as simple proportions:

$$\hat{P}_{il} = \frac{n_{il}}{n_l} \qquad (2)$$

where

$\hat{P}_{il}$ = proportion in length range or age l, period i;

n_{il} = number of fish in length range or age 1, period i;

n_l = total number sampled in length or age class 1;

and the number of Dolly Varden by sexual maturity or age component:

$$\hat{N}_{il} = \hat{P}_{il} N_T \quad (3)$$

where

$\hat{N}_{il}$ = estimated number of fish in length range or age class 1, period i;

N_T = weir count during period i.

The length frequency of immigrating Dolly Varden has been shown to change over time (Larson et al. 1988), therefore the estimated population of each sexual maturity component was weighted temporally in three, 2-week periods from July through mid-August. The time frame, July through mid-August, was selected because it was common to all 5 years of weir operation.

Annual survival to the weir and instantaneous dynamic rates were computed from estimates of numbers by age of the immigration through the weir. Age data for 1988 are from weir morts and were not stratified temporally, however, 1989-1991 estimates are weighted temporally in three, 2-week periods from July through mid-August.

These data were modeled to compute estimates of annual survival (S) by age (Ricker 1975):

$$S = N_{[t+1,a+1]}/N_{[t,a]} \quad (4)$$

where

N = immigration through the weir,
t = year, and
a = age.

Annual mortality (A) was computed by subtraction:

$$A = 1 - S. \quad (5)$$

Annual fishing mortality or exploitation (E) was defined as fishing which occurs in the Anchor River below the weir. Currently, nearly all of the harvest occurs below the weir. Exploitation was computed from estimates of harvest (C) and immigration (N) by age:

$$E = C_{[t,a]}/(C_{[t,a]} + N_{[t,a]}). \quad (6)$$

The instantaneous rate of total mortality (Z) was computed as (Ricker 1975):

$$Z = -\ln(S). \quad (7)$$

Instantaneous annual fishing mortality (F) was computed from the Baranof catch equation:

$$C = N*(F/Z)*(1-e^{-Z}) \quad (8)$$
$$F = (C/(1-e^{-Z}))*(Z/N)$$

Instantaneous natural mortality (M) was computed by subtraction:

$$M = Z - F. \quad (9)$$

RESULTS

Sport Fishery

Beginning in 1991, the daily bag and possession limit for Dolly Varden was reduced from five to two fish on Anchor River, Deep Creek, Ninilchik River, and Stariski Creek. This regulatory change was implemented by the Board of Fisheries to protect the Dolly Varden spawning stocks of these streams. Previous studies (Larson 1990 and 1991) indicated anglers selectively harvest Dolly Varden of spawning size and that the average spawner exploitation rate since 1987 was 25%. The reduction in bag limit from five fish to two reduced the harvest of spawners to less than 12% during 1991.

A creel survey was conducted in selected areas (Figure 2) of the lower 3 km of the Anchor River from 2 July to 2 September 1991. Angler effort, catch and harvest were estimated for the entire creel survey area (Table 2 and Appendices B1 and B2). Separate estimates for areas upstream and downstream of the weir site were prevented due to an insufficient quantity of creel data from anglers fishing upstream of the weir. Estimated effort during this period was 23,533 angler-hours, while Dolly Varden catch and harvest were 5,995 fish and 1,520 fish, respectively.

A total of 290 completed anglers, who targeted Dolly Varden, were surveyed for demographic information from 2 July through 1 September (Table 3 and Appendix B3). An estimated 49% of the anglers were residents of Alaska and they accounted for 49% of the Dolly Varden harvest. This is a 7% reduction in resident anglers and a 30% reduction in resident harvest from 1990. Of the Alaskan residents, an estimated 35% lived more than 35 km from the Anchor River and accounted for 15% of the resident harvest. An estimated 3% of all anglers used bait, 80% used lures, and 17% used both bait and lures. Anglers who used bait were only slightly more successful in harvesting Dolly Varden than those using lures. While 3% of the anglers used bait, they accounted for 5% of the total harvest. Of the completed anglers interviewed, 94% indicated they fished downstream of the weir structure and those who fished downstream of the weir accounted for 99% of the total recorded harvest.

Table 2. Anchor River Dolly Varden effort, catch, and harvest estimates, 1991.

	Date	Period	Number of Days		Mean	Total	Variance Components			Total Variance	Relative Precision[b]
			Total	Sampled			S_{1h}^2[a]	Stage 1	Stage 2		
Effort	02 Jul-01 Sep	A	63	16	161	10,143	26,853	4,969,545	116,739	5,086,284	44
		B	63	20	213	13,390	33,083	4,481 121	79,783	4,560,904	31
	Total					23,533				9,647,188	24
Catch	02 Jul-01 Sep	A	63	16	36	2,296	2,985	552,417	70,233	622,650	67
		B	63	20	59	3,698	10,366	1,404,028	104,782	1,508,810	65
	Total					5,995				2,131,460	48
Harvest	02 Jul-01 Sep	A	63	16	16	978	663	122,742	12,447	135,189	74
		B	63	20	9	542	139	18,811	3,867	22,678	54
	Total					1,520				157,867	51

[a] Variance among days sampled (equation 13).
[b] Relative precision = (square root (variance) X 1.96/Estimate) X 100.

Table 3. Summary of completed angler responses to questions on the use of terminal tackle, residency, and harvest from 2 July through 1 September 1991. Anglers were targeting Dolly Varden.

	Terminal Tackle Used by Interviewed Anglers				Residency			
					Resident			Non Resident
	Bait Only	Lures Only	Both Bait and Lures	Total	Local[a]	Non Local[b]	Total	Total
Responses:	10 (3%)	231 (80%)	49 (17%)	290	91 (65%)	50 (35%)	141 (49%)	149 (51%)
Number Fish Caught:	39 (5%)	610 (75%)	166 (20%)	815	341 (85%)	58 (15%)	399 (49%)	415 (51%)

[a] Alaskan resident angler living less than 35 km from Anchor Point.
[b] Alaskan resident angler living greater than 35 km from Anchor Point.

Anchor River Weir

The Anchor River weir was operated from 4 July through 15 August 1991. River water levels varied considerably throughout the duration of the weir operation. High water conditions from 1-4 August necessitated removal of the rigid weir pickets for approximately 72 hours to prevent damage to the weir structure. Depth readings were recorded daily at 2200 hours from 4 July through 14 August and temperature readings were recorded continually with a thermograph from 5 July through 8 August. Water depth and temperature recorded at the upstream trap location (Appendix B4) varied from 35 cm to 90 cm and 7.9°C to 17.6°C, respectively. Daily water temperature readings varied from 1.2°C to 6.6°C within a 24-hour period. In comparison, the water depth was greater and water temperature colder than in previous years (Nelson et al. 1987, Larson et al. 1988, Larson and Balland 1989, Larson 1990 and 1991).

A total of 18,002 Dolly Varden approximately 200 mm or greater in length were counted passing upstream of the Anchor River weir (Appendix B5). In addition, an unknown number of Dolly Varden passed upstream of the weir during the first 3 days of August when portions of the rigid weir were removed due to high water conditions. This unknown segment of the population was considered to be significant, perhaps as many as 3,000 fish, because the high water occurred during a peak migration period. The peak of the immigration occurred in late July, with 50% of the run having passed the weir by 28 July (Figure 3). The timing of immigrating Dolly Varden during 1991 was the latest recorded since 1987 (Figure 4).

One-way analysis of variance (Snedecor and Cochran 1967) was used to test the null hypothesis that there was no change in mean length of fish across weeks at the weir. The mean length of immigrating Dolly Varden sampled ($n = 665$) at the weir did change significantly ($F = 11.4$, $P < 0.001$) over time (Figure 5). There was an inadequate number of Dolly Varden available during the first week to satisfy sampling requirements, therefore, only weeks two through six are represented in Figure 5. The mean length decreased each week from the second week through the fourth week and then increased slightly during the fifth week. These results are consistent with those observed in 1989 (Larson 1990) and 1990 (Larson 1991).

The length frequency between immigrating spawners and nonspawners differed significantly at age group 4 ($D_{max} = 0.76$; $n = 27, 5$; $P < 0.01$) and 5 ($D_{max} = 0.91$; $n = 34, 9$; $P < 0.01$), spawners being larger than nonspawners (Table 4). These results are consistent with those observed in 1989 and 1990.

The proportion of immigrating Dolly Varden nonspawners (female maturity index code 1) and spawners (female maturity index code 2) did not change significantly ($X^2 = 1.146$, $df = 1$, $P < 0.01$) over time (Table 5). These results differed with those observed in 1989 and 1990. However, with the late entry pattern observed during 1991, an insufficient number of samples were collected during the first 2-week sample period to be included in this analysis.

A total of 96 Dolly Varden were found dead in the downstream trap or along the upstream side of the weir face (Table 6). A subjective examination for possible causes of death revealed 58 fish (60.4%) with apparent hook wounds, 23 (24.0%) fish with predator injuries, 5 (5.2%) fish with unknown injuries,

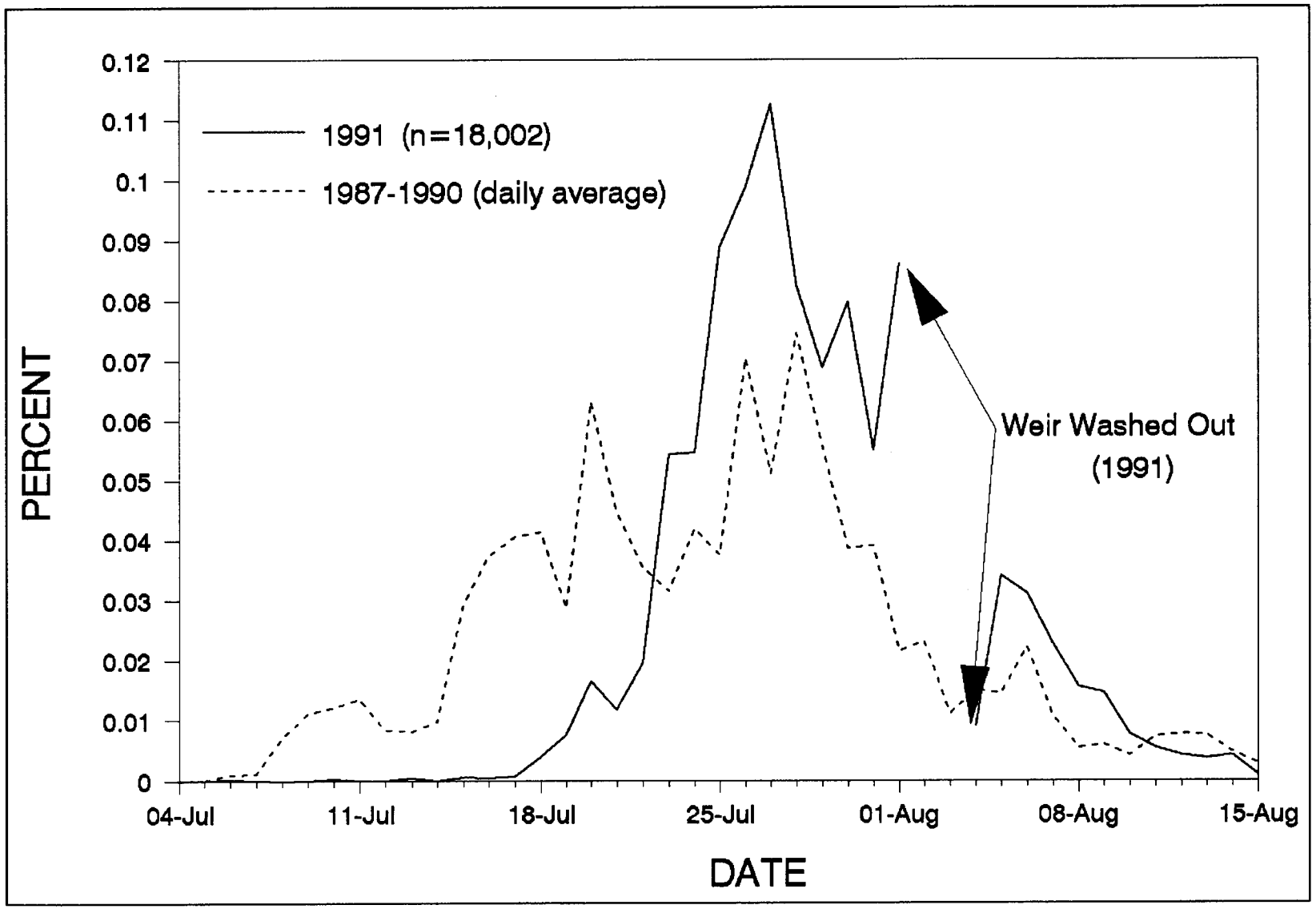

Figure 3. Comparison of Anchor River daily run timing. Fish were counted while passing upstream through the Anchor River weir, 1987-1991.

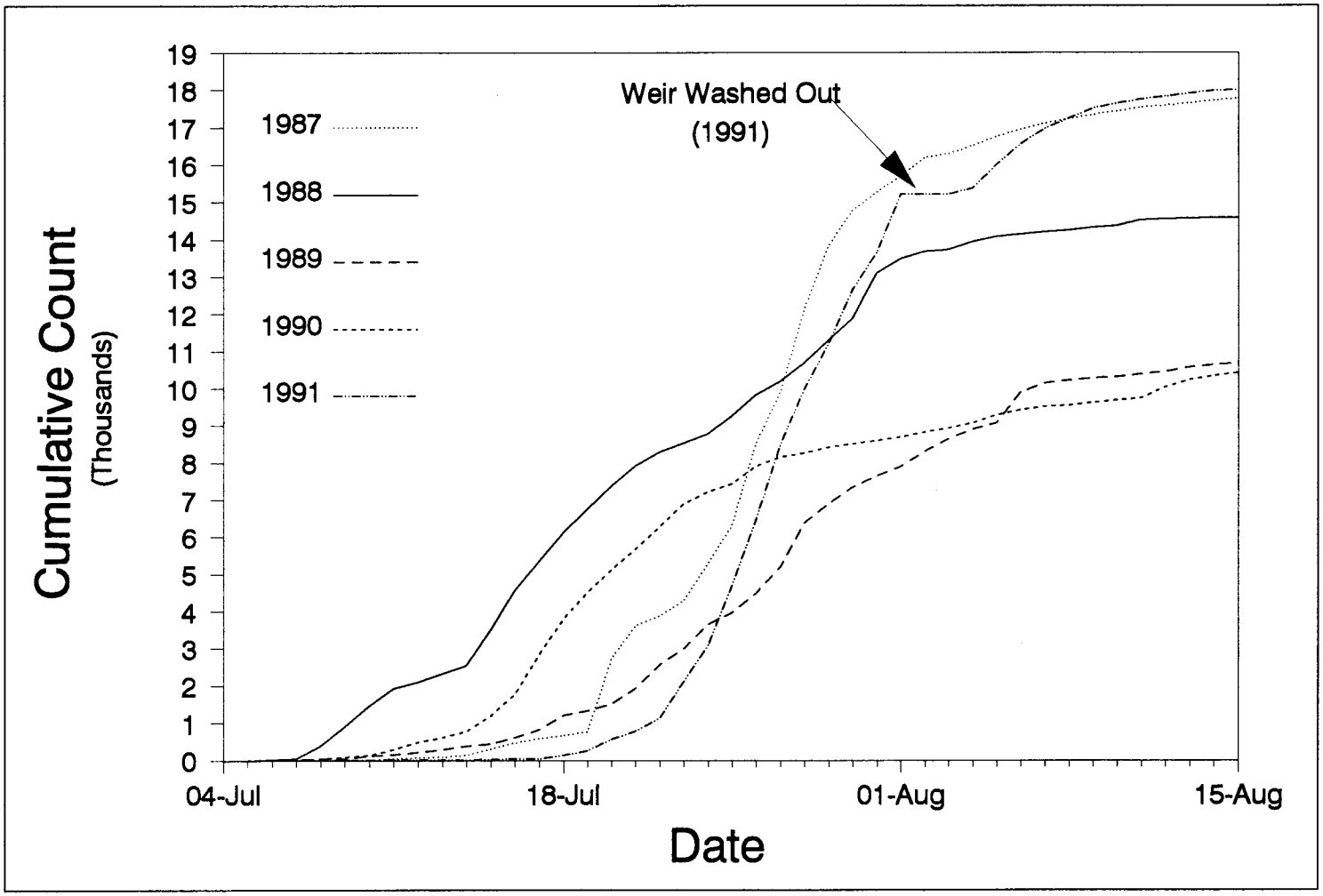

Figure 4. Anchor River Dolly Varden immigration run timing by cumulative percent from 5 July-15 August, 1987-1991.

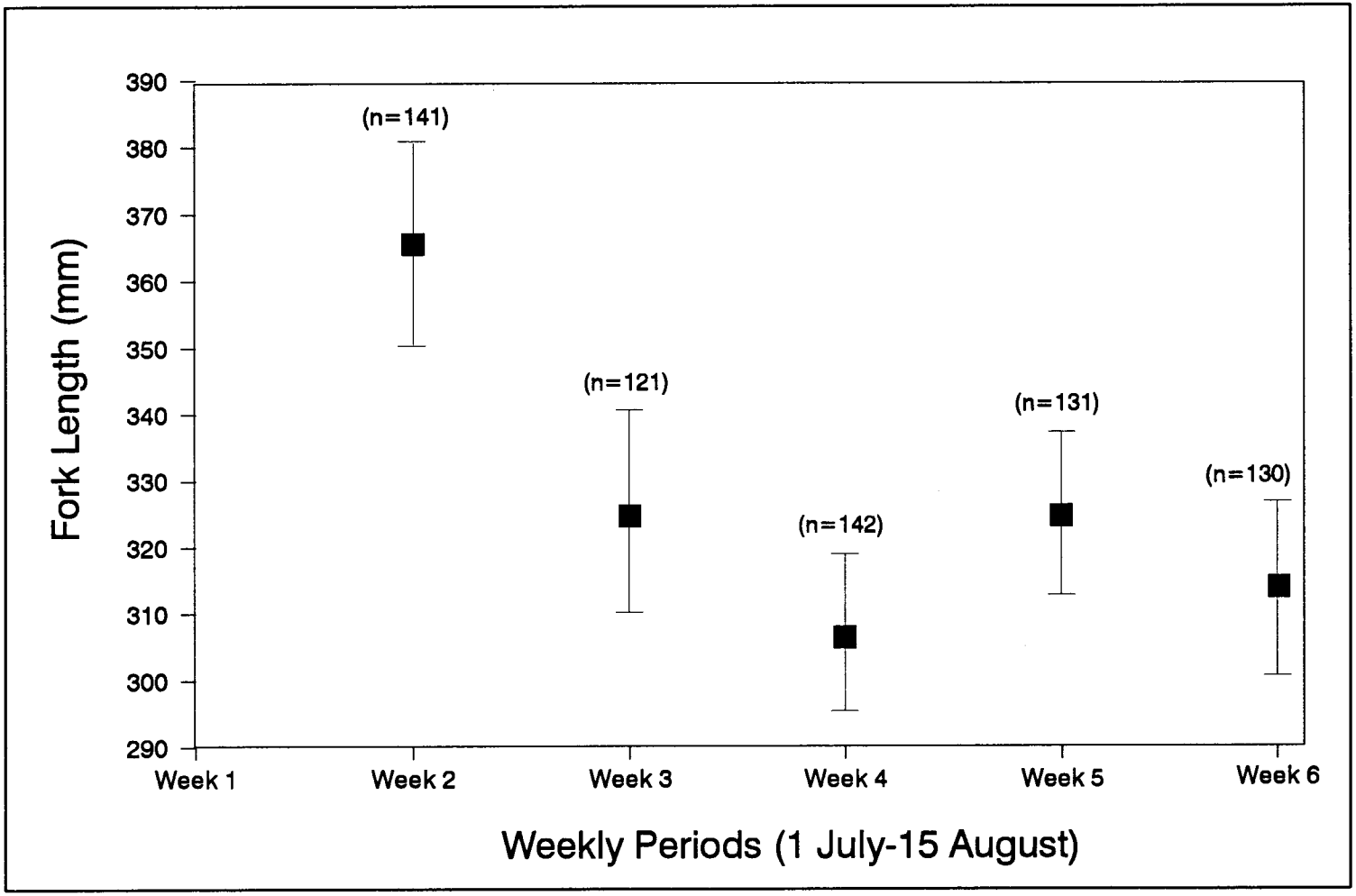

Figure 5. Mean length by period with 95% confidence intervals from Dolly Varden sampled moving upstream through the Anchor River weir, 1991.

Table 4. Mean length (millimeters) by age group and female sexual maturity of Dolly Varden collected at the Anchor River weir site and in the sport fishery, 1991.

Component	Age Group 2	3	4	5	6	7	8	9	10
Weir Samples (Upstream Trap)									
Nonspawner (Code 1)[a]									
Mean Length	250	228	269	271	228				
Standard Error		6.2	7.4	13.8					
Sample Size	1	14	27	9	1				
Potential Spawners (Code 5)									
Mean Length		303	305	338	392				
Standard Error			4.5	11.7					
Sample Size		1	7	15	1				
Spawner (Codes 2, 3 & 4)									
Mean Length			357	375	409	498	507		
Standard Error			21.4	6.7	9.3	25.6	35.3		
Sample Size			5	34	17	7	5		
Sport Harvest									
Nonspawner (Code 1)									
Mean Length		306	293	326		335			
Standard Error		17.5	10.3	9.0					
Sample Size		2	6	4		1			
Potential Spawners (Code 5)									
Mean Length		304	319	360	391	358	429		
Standard Error		31.0	9.0	23.3	3.5				
Sample Size		2	2	8	5	1	1		
Spawner (Codes 2, 3 & 4)									
Mean Length			337	411	432	468	394		550
Standard Error			15.2	9.3	9.3	21.9			
Sample Size			7	21	17	9	1		1

[a] Maturity Index Codes:
1 = immature female with egg diameter less than 0.90 mm,
2 = mature female with egg diameter greater than 1.75 mm,
3 = completely mature female (eggs easily stripped),
4 = completely spawned female,
5 = immature female but shows development, egg diameter greater than 0.90 mm and less than 1.75 mm.

Table 5. Maturity index summary of Dolly Varden sampled at the Anchor River fish weir and in the sport fishery with estimates of composition by period and maturity code for percent, mean length, and total numbers of fish, 1991.

	Female Maturity Code[a]																	
	1				2				3				4	5				
Period	Sample Size	%	Mean Length (mm)	Estimated Total Fish	Sample Size	%	Mean Length (mm)	Estimated Total Fish	Sample Size	%	Mean Length (mm)	Estimated Total Fish	Sample Size	Sample Size	%	Mean Length (mm)	Estimated Total Fish	Total Fish Sampled
Weir Samples																		
2-18 July	3	38	249	53	4	50	522	71	0			0	0	1	13	345	18	8
19-31 July	24	39	268	5,324	24	39	430	5,324	0			0	0	12	21	321	2,884	61
1-15 Aug	25	33	248	1,443	40	51	378	2,221	0			0	0	12	15	332	666	78
2 July-15 Aug	52	36	257	6,820	68	47	405	7,615	0			0	0	25	17	327	3,567	145
Sport Harvest																		
1-18 July	1	20	315		2	40	522		0				0	2	40	386		5
19-31 July	3	9	299		24	69	445		0				0	8	23	397		35
1 Aug-1 Sept	9	17	311		33	63	394		1	2	456		0	9	17	325		52
2 July-1 Sept	13	14	309	215	59	64	419	974	1	1	456	17	0	19	21	362	314	92

[a] Maturity index codes:
1 = immature female with egg diameter less than 0.9 mm,
2 = mature female with egg diameter greater than 1.75 mm,
3 = completely mature female (eggs easily stripped),
4 = completely spawned female,
5 = immature female but shows development, egg diameter greater than 0.5 mm and less than 1.75 mm.

Table 6. Injuries observed by length range from Dolly Varden sampled in the emigration through the Anchor River weir and from mortalities collected at the weir site, 1991.

Dolly Varden Mortalities Collected at the Weir Site

Length Range	No Injuries	%	Angler Wound	%	Net Wound	%	Unknown Injuries	%	Predator Injuries	%	Total
<200				0.0		0.0		0.0		0.0	0
200-249	2	2.1	9	9.4		0.0		0.0	2	2.1	13
250-299	5	5.2	18	18.8		0.0	1	1.0	5	5.2	29
300-349	1	1.0	19	19.8		0.0	4	4.2	7	7.3	31
350-399		0.0	8	8.3		0.0		0.0	3	3.1	11
400-449	1	1.0	2	2.1		0.0		0.0	3	3.1	6
450-499	1	1.0	2	2.1		0.0		0.0	2	2.1	5
500>		0.0		0.0		0.0		0.0	1	1.0	1
Total	10	10.4	58	60.4	0	0.0	5	5.2	23	24.0	96

Downstream Migration of Dolly Varden Moving through the Weir

Length Range	No Injuries	%	Angler Wound	%	Net Wound	%	Unknown Injuries	%	Predator Injuries	%	Total
<200	10	8.8	2	1.8		0.0		0.0		0.0	12
200-249	23	20.2	8	7.0	1	0.9	1	0.9	2	1.8	35
250-299	16	14.0	9	7.9		0.0		0.0	1	0.9	26
300-349	17	14.9	3	2.6		0.0		0.0	1	0.9	21
350-399	7	6.1	6	5.3		0.0		0.0		0.0	13
400-449	1	0.9	3	2.6		0.0		0.0	2	1.8	6
450-499		0.0	1	0.9		0.0		0.0		0.0	1
500>		0.0		0.0		0.0		0.0		0.0	0
Total	74	64.9	32	28.1	1	0.9	1	0.9	6	5.3	114

Injuries which resulted in lesions to the skin generally had topical evidence of a bacterial infection resembling furunculosis (a necrotic lesion which ulcerates to release lightly infectious reddish fluid). Although the percentage of fish with injuries in each category remained similar to those observed in 1990, the magnitude was reduced approximately 75%. Cooler water temperatures are suspect in the reduction of trauma caused from the different types of injuries.

A total of 114 Dolly Varden passed through the downstream trap from 4 July through 15 August (Appendix B6). The majority (73%) of these fish were less than 300 mm in fork length. When examined for injuries, 28.1% had apparent hook wounds (Table 6) and generally had topical evidence of a bacterial infection resembling furunculosis associated with them. This is a reduction of nearly 20% from furunculosis observations during 1990. None of the injured fish released downstream with bacterial infections were observed returning through the upstream trap after release.

Biological Data

Dolly Varden sampled from the sport harvest and the upstream weir trap were analyzed for length, age, sex, and relative maturity. All weir samples were measured for length and some were sacrificed to estimate age, sex, and relative maturity.

Dolly Varden analyzed for age from the immigration through the weir and the sport fishery ranged in age from 2 to 10 years (Table 7 and Appendix B7). The age composition between weir and sport fishery samples was significantly different (X^2 = 21.43, df = 4, P > 0.005). Fish less than age 5 were more prevalent (45%) in weir samples than in the sport harvest (27%). This supports the hypothesis that anglers are size selective when harvesting fish.

Immigrating male Dolly Varden were predominantly age 4 and females were predominantly age 5 (Figure 6). The number of fish older than 5 dropped precipitously and the combined year-classes from 7 through 9 accounted for less than 10% of the run. These results are consistent with those observed in 1990 and suggest a low frequency of repeat spawning due to high natural or fishing mortality.

Of 240 fish sampled at the weir, 60% were females and of 188 fish sampled in the sport harvest, 52% were females. These ratios did not change significantly over time when compared in biweekly periods (Table 8). Contradictory to 1990 findings, the sex ratios between the immigration through the weir and the sport harvest were not significantly different either.

Estimates of the Dolly Varden immigration through the weir indicate that about 47% were spawners, 17% potential spawners, and 36% nonspawners (Table 5, Figure 7, and Appendix B8). There was a significant difference (X^2 = 13.16, df = 2, P > 0.005) in the total percentage of each maturity index category observed between weir samples (n = 145) and the sport harvest (n = 92) (Table 5). There were proportionately fewer nonspawners in the sport harvest than the weir samples. This was contradictory to 1990 results. An estimated 88% of the sport harvest were over 300 mm in fork length (Table 9) and generally fish greater than 300 mm sampled from the immigration through the weir were spawners (Table 4 and Larson 1990 and 1991).

Table 7. Age and sex compositions of Dolly Varden collected at the weir site and in the sport harvest on the Anchor River during 1991.

Component	Age Group 2	3	4	5	6	7	8	9	10	Total
Weir Samples (Upstream Trap)										
Male										
Percent	1.0	10.4	41.7	28.1	12.5	5.2	0.0	1.0	0.0	40.0
Sample Size	1	10	40	27	12	5	0	1	0	96
Female										
Percent	0.7	10.4	27.8	39.6	13.2	4.9	3.5	0.0	0.0	60.0
Sample Size	1	15	40	57	19	7	5	0	0	144
Sexes Combined										
Percent	0.8	10.4	33.3	35.0	12.9	5.0	2.1	0.4	0.0	100.0
Sample Size	2	25	80	84	31	12	5	1	0	240
Sport Harvest										
Male										
Percent	0.0	3.3	31.1	35.6	23.3	5.6	0.0	1.1	0.0	47.9
Sample Size	0	3	28	32	21	5	0	1	0	90
Female										
Percent	0.0	4.1	16.3	36.7	25.5	13.3	3.1	0.0	1.0	52.1
Sample Size	0	4	16	36	25	13	3	0	1	98
Sexes Combined										
Percent	0.0	3.7	23.4	36.2	24.5	9.6	1.6	0.5	0.5	100.0
Sample Size	0	7	44	68	46	18	3	1	1	188

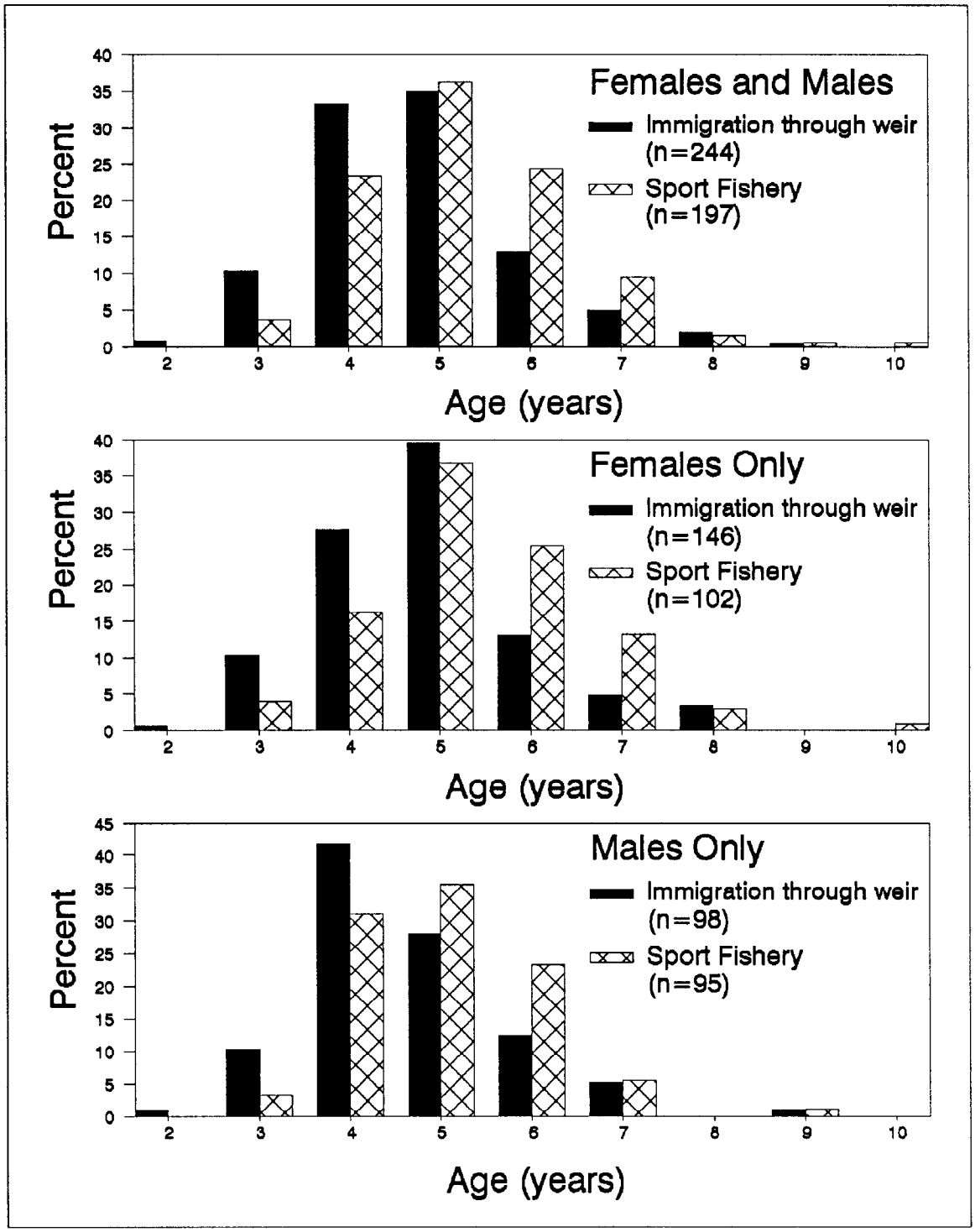

Figure 6. Age and sex composition of Dolly Varden sampled at the Anchor River weir site and in the sport fishery, 1991.

Table 8. Estimated sex ratios of Anchor River Dolly Varden sampled biweekly from the weir site and in the sport fishery, 1991.

Sex	Fish Weir: 2 July-18 July Count	%	19 July-31 July Count	%	1 Aug-15 Aug Count	%	Total Count	%	Estimated Weir Population[a]
Male	6	43	48	44	44	36	98	40	7,230
Female	8	57	60	56	77	64	145	60	10,772
Total:	14		108		121		243		18,002

Sex	Sport Fishery: 2 July-16 July Count	%	17 July-31 July Count	%	1 Aug-1 Sept Count	%	Total Count	%	Estimated Harvest
Male	3	38	48	52	44	46	95	48	733
Female	5	63	45	48	52	54	102	52	787
Total:	8		93		96		197		1,520

[a] The estimated weir population is based on the actual number of Dolly Varden counted passing through the weir and does not account for fish that may have passed upstream during a three-day period when a portion of the weir was removed.

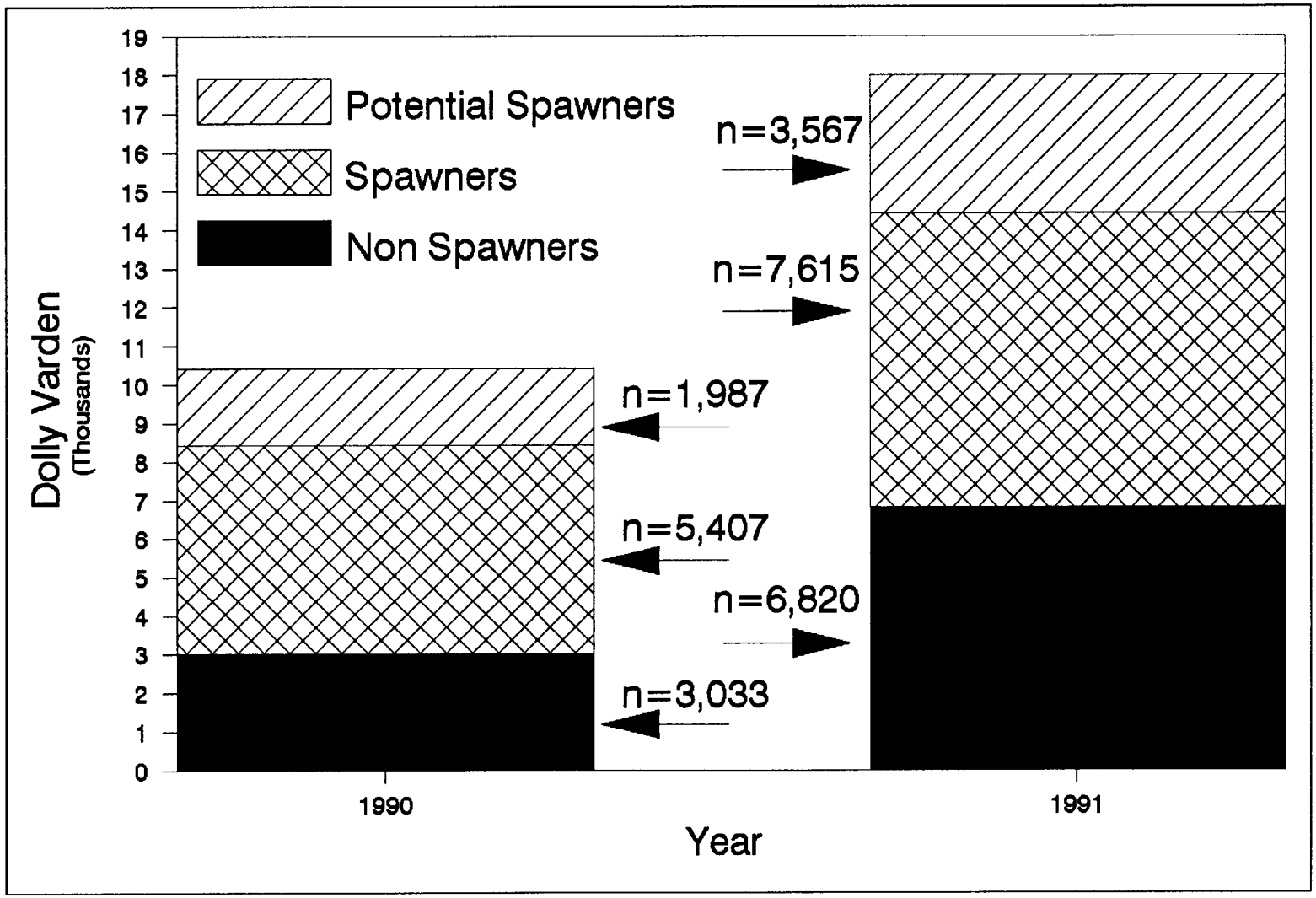

Figure 7. Maturity component of immigrating Dolly Varden sampled at the Anchor River weir, 1990-1991.

Table 9. Number of Dolly Varden sampled from the upstream trap, sport harvest, mortalities recovered at the weir site, and downstream trap, by length range, Anchor River, 1991.

	Upstream Trap		Sport Harvest		Mortalities		Downstream Trap	
Length Range	Count	%	Count	%	Count	%	Count	%
<200	9	1	0	0	0	0	12	11
200-249	122	19	1	1	13	14	34	30
250-299	126	19	22	11	29	30	26	23
300-349	162	25	50	25	31	32	21	19
350-399	111	17	54	27	11	11	13	12
400-449	68	10	37	19	6	6	6	5
450-499	34	5	25	13	5	5	1	1
500>	23	4	11	6	1	1	0	0
Total	655	100	200	100	96	100	113	100

Dolly Varden harvested by the fishery averaged 20-80 mm larger than those sampled at the weir (Table 4) in all age classes except age 7, thus indicating a bias by anglers to harvest larger fish. The length of age-5 nonspawners (D_{max} = 0.88; n = 9, 4; $P < 0.01$) and age-5 (D_{max} = 0.39; n = 33, 32; $P < 0.05$) and -6 spawners (D_{max} = 0.47; n = 17, 17; $P < 0.05$) harvested by the fishery were significantly different from fish sampled through the weir (Figure 8).

Tag recoveries from Dolly Varden tagged on lower peninsula streams since 1986 total 1,014 with only one tag recovered during 1991 (Table 10 and Appendix B9). To date, 82% of the total recoveries were made 1 year after tagging and 18% 2 or more years later (Appendix B9). These results may change slightly as additional data are collected in upcoming years, however, few Dolly Varden were tagged after 1988 and these results are not expected to change radically. Only fish of spawning size (at least 300 mm in fork length) at the time of tagging were included in these estimates.

Stock Structure and Dynamic Rates

The estimated spawner component of immigrating Dolly Varden sampled at the Anchor River weir from 4 July through 15 August decreased each year from 1987 through 1990. However, from 1990 to 1991, the number of spawners increased over two-fold (Table 11 and Figure 9). This increase in spawners during 1991 is attributed mainly to an influx of age-5 spawners, the predominant age class (Table 4 and Table 7).

The combined potential spawner and nonspawner components have ranged from approximately 6,000 to 7,000 fish annually during the period 1987-1990 to 9,648 fish in 1991. These fish are considered to be of mixed origin (Armstrong 1965) and therefore, variations in abundance are not necessarily reflective of the Anchor River stock status.

All but one of the estimates of annual survival through age 5 were greater than one (Table 12). Fish younger than age 5 were incompletely recruited to the spawning population (Figure 8 and Larson 1991). As the proportion of spawning fish increases with age for any cohort, increasing numbers of that particular cohort should annually return to the Anchor River to spawn. The nine estimates of annual survival for ages 6-8 were all less than one and show a strong decreasing trend as fish age from age 6 to age 8. Based on our maturity sampling, these age classes are comprised virtually entirely of spawners. Per our hypothesis of stock structure, these fish should annually return to spawn and these estimates seem a realistic expression of that phenomenon. While age-9 and older fish should fit the same pattern as that described for age-6 to -8 fish, annual survival for these age classes varies widely from 0 to 2.3 and is likely attributable to rare event sampling; these age classes are found in only trace levels (less than 1%) (Table 12).

Exploitation by the sport fishery (E) (Table 13) indicates that anglers preferred to harvest fish of spawning age, primarily age 5 and older. Of particular concern is the 1990 fishery when fewer spawners were estimated to have returned to the Anchor River since the weir operation began in 1987. Exploitation by age was consistently highest during 1990, particularly among the spawning stock.

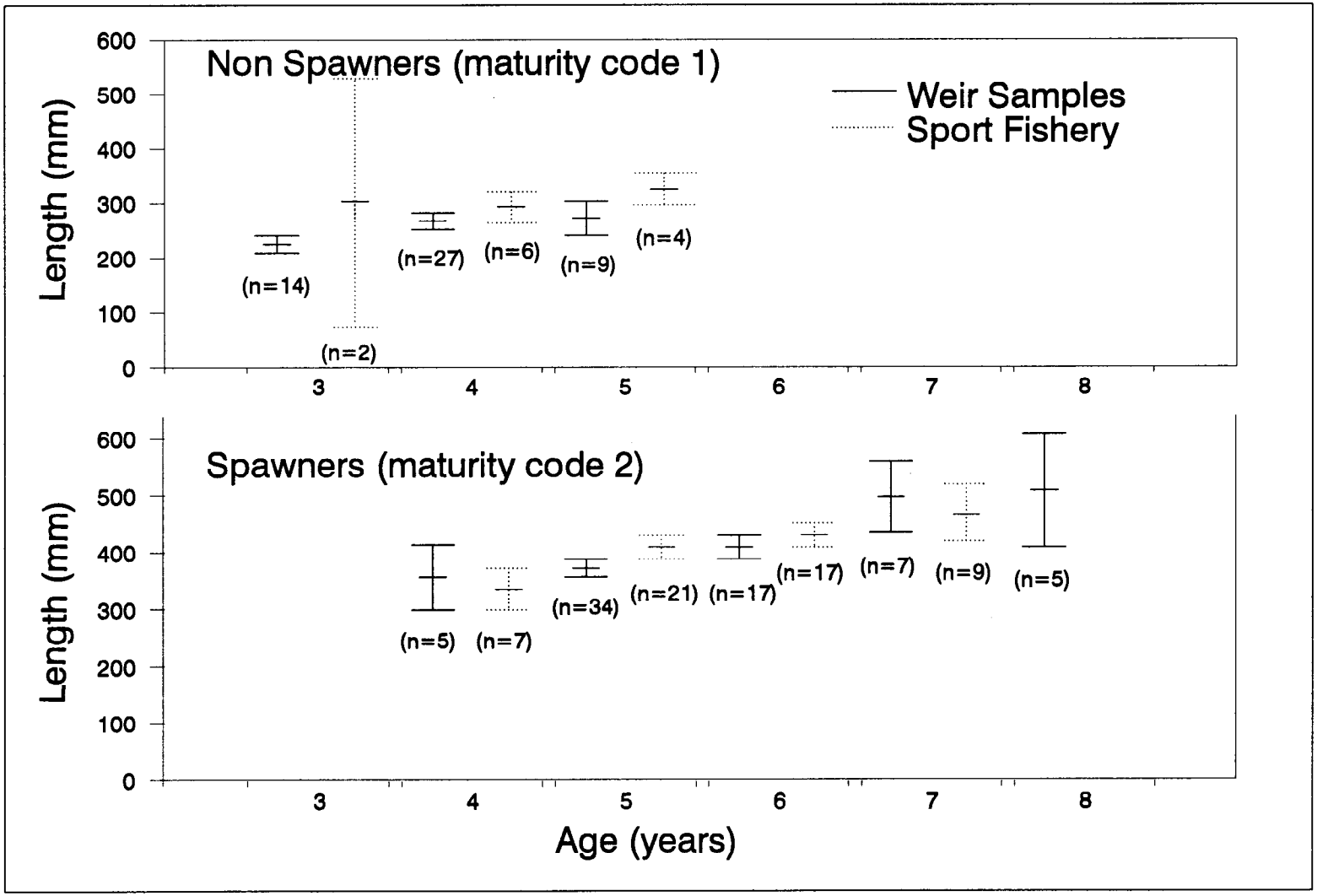

Figure 8. Mean length by age with 95% confidence intervals from non spawner and spawner Anchor River Dolly Varden sampled at the weir and in the sport fishery, 1991.

Table 10. Summary of lower Kenai Peninsula Dolly Varden tag and tag recovery, 1986-1991.

Tagging Data					Recovery Data																																		
					1987									1988														1989						1990					1991	
					AR[a]				DC[b]	NR[c]		Salt[d]	AR				CRC[e]	NR			KR[f]	Salt			AR		Salt			AR		KSR[g]	Salt		Salt	
Year	Site	Month	No. Days	No. Tagged	Jul	Aug	Sep	Oct	Aug	Oct	Nov	May	Jul	Aug	Sep	Oct	Sep	Jul	Aug	Sep	Jul	May	Jun	Jul	Aug	Apr	Jun	Jul	Jul	Aug	Jul	Apr	May	Apr	Total
1986	Anchor R.	Oct	2	79	2			1				1																										
1987	Anchor R.	Jul	24	1,690	53	35	8	5			1							6				3																
		Aug	30	1,412		189	21	10					18	1							1	2	1	2			1		3								
		Sep	8	105									2																								
	Deep Cr.	Jul	2	36		1		2	1				2																								
		Aug	1	4																																	
		Sep	1	29																																	
	Ninilchik	Jul	2	13																																	
		Sep	5	104				2		1								1						1														
1988	Anchor R.	Jul	25	2,969									278	124	3	1		1						36	3	1	1		17	1		3	1		470
		Aug	3	54										3															1						4
	Ninilchik	Jul	17	734													1	117	18	2																138
		Aug	8	35																			1					1								1
1989	Anchor R.	Jul	2	3																																	
		Aug	19	262																					14						1			1	15
		Sep	2	4																																	
		Oct	3	7																																	
		Nov	3	8																																	
		Total		7,548	55	225	37	20	1	1	1	1	300	128	3	1	1	125	18	2	1	5	1	39	17	1	2	1	21	1	1	3	1	1	1,014

[a] AR = Anchor River
[b] DC = Deep Creek
[c] NR = Ninilchik River
[d] SALT = Salt Water
[e] CRC = Crooked Creek
[f] KR = Kenai River
[g] KSR = Kasilof River

Table 11. Estimated sexual maturity of immigrating Dolly Varden sampled at the Anchor River weir from 4 July through 15 August, 1987-1991. Sexual maturity based on length frequency data collected from tagging studies and length sampling schedules.

			Non Spawners (<300mm)			Potential Spawners (300-349mm)			Spawners (>349mm)			
Year	Period	Weir Count	Sample Size	%	Estimated Population	Sample Size	%	Estimated Population	Sample Size	%	Estimated Population	Source of Length Sample
1987	July 4-17	596	17	3.8%	23	57	12.9%	77	369	83.3%	496	
	July 18-31	14,688	215	17.3%	2,534	237	19.0%	2,794	794	63.7%	9,360	
	Aug 1-15	2,490	431	39.4%	982	264	24.2%	601	398	36.4%	907	
	Total:	17,774	663	23.8%	3,539	558	20.1%	3,472	1,561	56.1%	10,763	Tagging: n=2,782
1988	July 4-17	5,323	105	7.8%	417	431	32.2%	1,712	804	60.0%	3,194	
	July 18-31	7,713	337	29.3%	2,258	403	35.0%	2,701	411	35.7%	2,754	
	Aug 1-15	1,480	8	14.8%	219	8	14.8%	219	38	70.4%	1,041	
	Total:	14,516	450	17.7%	2,895	842	33.1%	4,632	1,253	49.2%	6,989	Tagging: n=2,545
1989	July 4-17	846	2	1.9%	16	11	10.4%	88	93	87.7%	742	
	July 18-31	6,812	69	24.7%	1,685	78	28.0%	1,904	132	47.3%	3,223	
	Aug 1-15	3,034	156	35.3%	1,071	206	46.6%	1,414	80	18.1%	549	
	Total:	10,692	227	27.4%	2,771	295	35.7%	3,406	305	36.9%	4,514	AWL: n=827
1990	July 4-17	2,859	20	15.0%	430	13	9.8%	279	100	75.2%	2,150	
	July 18-31	5,760	68	65.4%	3,766	18	17.3%	997	18	17.3%	997	
	Aug 1-15	1,808	127	70.2%	1,269	32	17.7%	320	22	12.2%	220	
	Total:	10,427	215	51.4%	5,465	63	15.1%	1,596	140	33.5%	3,366	AWL: n=418
1991	July 4-17	68	8	36.4%	25	4	18.2%	12	10	45.5%	31	
	July 18-31	13,604	59	26.7%	3,632	58	26.2%	3,570	104	47.1%	6,402	
	Aug 1-15	4,330	79	28.7%	1,244	74	26.9%	1,165	122	44.4%	1,921	
	Total:	18,002	146	28.2%	4,900	136	26.3%	4,748	236	45.6%	8,354	AWL: n=518

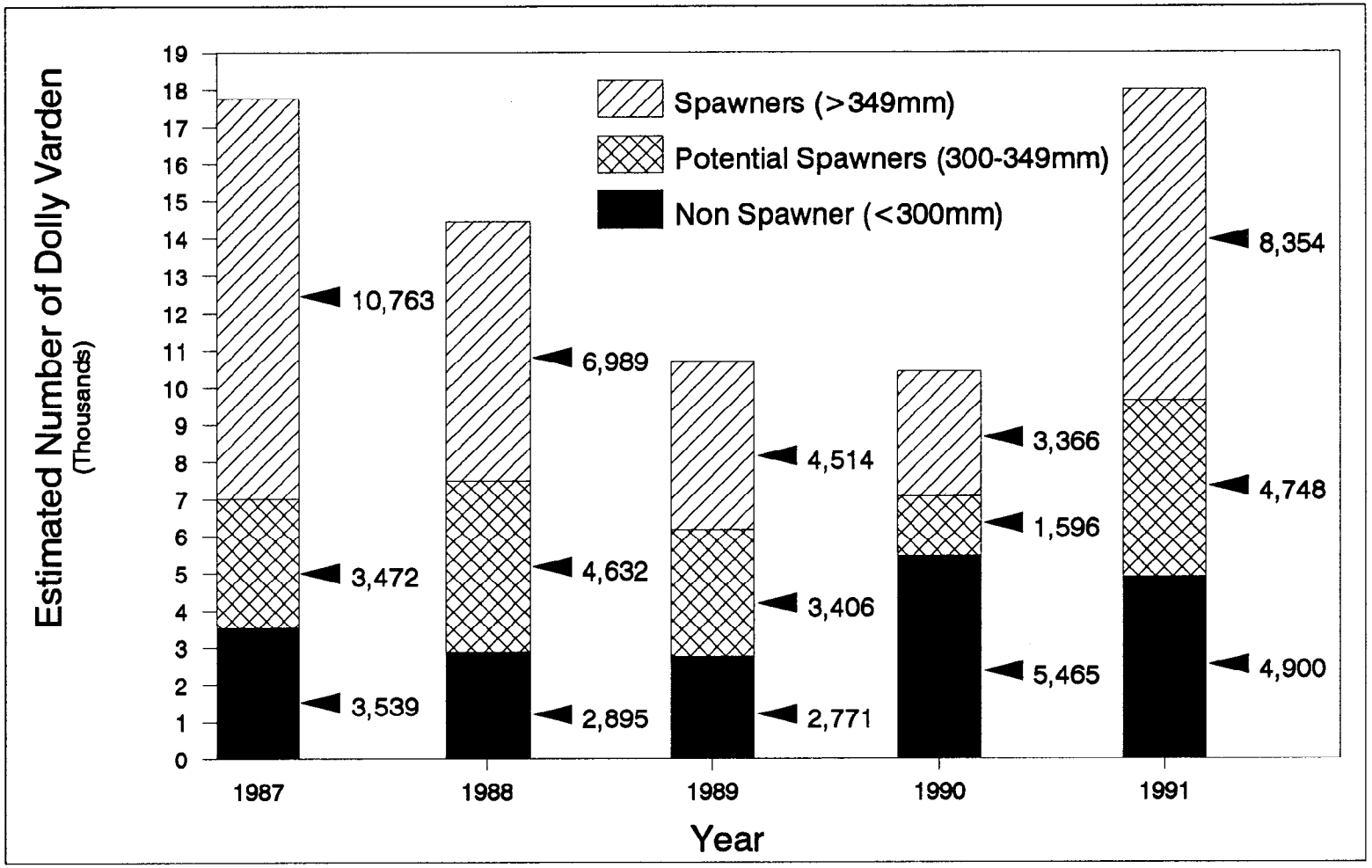

Figure 9. Estimated sexual maturity component of immigrating Dolly Varden sampled at the Anchor River weir from 4 July through 15 August, 1987-1991. Sexual maturity based on length frequency data collected from tagging studies and length sampling.

Table 12. Anchor River Dolly Varden estimates by age of percent composition, weir counts, annual survival and annual mortality from 1 July through 15 August, 1988-1991. Age composition based on fish mortalities collected on the weir face (1988) and random sampling schedules (1989-1991).

		Percent by Age									
Year	N	2	3	4	5	6	7	8	9	10+	Total
1988	622	0.4	5.8	23.1	48.5	16.3	4.7	0.5	0.7	0.0	100.0
1989	557	0.5	6.0	22.8	26.0	32.3	9.7	2.0	0.2	0.0	99.5
1990	366	0.5	21.0	29.0	27.9	13.9	6.8	0.3	0.3	0.3	100.0
1991	240	0.8	10.4	33.3	35.0	12.9	5.0	2.1	0.4	0.0	99.9

		Weir Counts by Age									
Year	N	2	3	4	5	6	7	8	9	10+	Total
1988	622	58	842	3,353	7,040	2,366	682	73	102	0	14,516
1989	557	71	750	2,492	2,681	3,520	933	231	14	0	10,692
1990	366	38	1,961	2,580	3,409	1,595	769	25	25	25	10,427
1991	240	164	1,663	6,262	6,229	2,185	1,040	423	36	0	18,002

ANNUAL SURVIVAL BY AGE (S)

	Age							
Timeframe	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10
1988 - 1989	12.917	2.960	0.800	0.500	0.394	0.339	0.193	0.000
1989 - 1990	27.620	3.440	1.368	0.595	0.218	0.027	0.108	1.786
1990 - 1991	43.763	3.193	2.414	0.641	0.652	0.550	1.440	0.000

ANNUAL MORTALITY BY AGE (A)

	Age							
Timeframe	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10
1988 - 1989	-11.92	-1.960	0.200	0.500	0.606	0.661	0.807	1.000
1989 - 1990	-26.62	-2.440	-0.368	0.405	0.782	0.973	0.892	-0.786
1990 - 1991	-42.76	-2.193	-1.414	0.359	0.348	0.450	-0.440	1.000

Table 13. Anchor River sport harvest estimates of percent composition, harvest and annual fishing mortality by age downstream of the fish weir, 1988-1991.

		Percent by Age								
Year	N	2	3	4	5	6	7	8	9	10+	Total
1988	224		2.7	26.3	47.7	17.8	3.6	1.4	0.5		100.0
1989	60		6.7	30.0	25.0	31.6	5.0	1.7			100.0
1990	87		9.2	27.6	41.3	9.2	9.2	2.3	1.2		100.0
1991	188		3.7	23.4	36.2	24.5	9.6	1.6	0.5	0.5	100.0

		Numbers by Age									
Year	N	2	3	4	5	6	7	8	9	10+	Total
1988	224	0	58	567	1,028	384	78	30	11	0	2,156
1989	60	0	71	316	263	333	53	18	0	0	1,053
1990	87	0	195	586	877	195	195	49	25	0	2,124
1991	188	0	56	356	550	372	146	24	8	8	1,520

ANNUAL FISHING MORTALITY (E) OR EXPLOITATION

	Age							
Years	3	4	5	6	7	8	9	10
1988	0.065	0.145	0.127	0.140	0.102	0.294	0.096	-
1989	0.086	0.113	0.089	0.086	0.053	0.072	0.000	-
1990	0.091	0.185	0.205	0.109	0.203	0.661	0.505	0.000
1991	0.033	0.054	0.081	0.146	0.123	0.054	0.174	1.000

Since the only values of S that were within realistic estimates were those for ages 6-8, these are the only instantaneous rates that have meaning. The instantaneous rates of total mortality (Z) increased as fish aged beyond age 5 (Table 14).

No trends were evident in instantaneous annual fishing mortality (F) downstream of the weir (Table 14) and the values were fairly consistent across years and age. Again, 1990 stood out with the highest values which correspond to the high values of total mortality (Z) in 1990.

Instantaneous natural mortality (M) (Table 14) was approximately an order of magnitude higher than the values of F for ages 6 through 8. This indicates that the number of deaths due to fishing was much lower than from natural causes. These results support the literature which is fairly emphatic that mortality due to spawning is high.

DISCUSSION

Fishery

The reduction in the Dolly Varden daily bag limit from five to two reduced the 1991 harvest nearly 30% from 1990 levels. These results were predicted (Larson 1991) provided that effort remained at the 1990 level. Effort varied approximately 1% between years. This harvest reduction occurred even with a doubling in run strength from one year to the next. This suggests that angler harvest is a function of effort and not necessarily a function of fish abundance.

The Dolly Varden catch increased approximately 14% from 1990 to 1991. This increase, in conjunction with a 30% decrease in harvest, indicates an overall increase in hook-and-release practices. As a result, mortality associated with hook-and-release practices was expected to increase. Surprisingly, there was a 78% decrease in the number of fish mortalities recovered at the weir site displaying hook injuries (Table 6).

Hook-and-release mortality as it relates to Anchor River Dolly Varden is not well understood. Mortality probably varies from season to season depending on a variety of environmental and physical factors. Physical injury, disease, temperature, pH, dissolved oxygen concentrations and the amount and nature of suspended solids are all factors that can affect fish mortality and most of these are probably interrelated. As an example, when water temperatures rise, as they often do during July and August, dissolved oxygen levels drop and mortality can be expected to increase. Fish are poikilotherms and thus are dependent on water temperature for many of their bodily functions. Cool water temperatures are preferred and water temperatures were cooler during 1991 than in previous years and are suspect in the reduction of trauma caused by the different types of injuries inflicted during 1991.

A greater understanding of how hook-and-release practices impact lower Kenai Peninsula Dolly Varden could aide in the management of these stocks. Presently, nearly all hook-and-release activity occurs downstream of the weir site, an intertidal area where fish are already under stress from the biochemical requirements of adjusting from salt water to fresh water. The

Table 14. Anchor River Dolly Varden instantaneous estimates of annual, fishing and natural mortality, 1988-1991.

INSTANTANEOUS ANNUAL MORTALITY (Z)

	Age							
Timeframe	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10
1988 - 1989	-2.559	-1.085	0.224	0.693	0.931	1.083	1.646	-
1989 - 1990	-3.319	-1.235	-0.313	0.519	1.521	3.620	2.224	-0.580
1990 - 1991	-3.779	-1.161	-0.881	0.445	0.428	0.598	-0.365	-

INSTANTANEOUS ANNUAL FISHING MORTALITY (F)

	Age							
Timeframe	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10
1988 - 1989	0.261	0.208	0.088	0.066	0.034	0.043	0.000	-
1989 - 1990	0.343	0.396	0.300	0.093	0.108	0.195	0.275	0.000
1990 - 1991	0.131	0.096	0.133	0.135	0.112	0.042	0.252	-

INSTANTANEOUS ANNUAL NATURAL MORTALITY (M)

	Age							
Timeframe	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10
1988 - 1989	-2.819	-1.293	0.136	0.628	0.896	1.040	1.646	0.000
1989 - 1990	-3.662	-1.631	-0.613	0.426	1.413	3.425	1.948	-0.580
1990 - 1991	-3.910	-1.257	-1.014	0.309	0.315	0.556	-0.617	0.000

affect of additional stress invoked from hook-and-release practices remains unknown. Quantifying hook-and-release mortality would help managers understand what the total inriver exploitation of these stocks may be.

Stock Structure and Abundance

Major overwintering areas and movement patterns of lower Kenai Peninsula Dolly Varden are still not well understood. My limited tagging data indicate that Dolly Varden interact with all local streams and range from the Kenai River drainage to the north and the English Bay drainage to the south and east of the Anchor River. Within this range there are several lake systems that could be major overwintering lakes, however, only English Bay Lakes have a major anadromous Dolly Varden fishery associated with it, a native spring subsistence fishery. As a result, I feel the importance, if any, of this lake system to all lower Kenai Peninsula Dolly Varden should be determined.

These estimates of annual survival support the model of stock structure for Anchor River Dolly Varden. To summarize, only spawning fish annually return to the Anchor River and these fish are primarily 300 mm and greater which corresponds to age 5 and older. The smaller, younger fish are immature and do not necessarily exhibit fidelity to the Anchor River until they are ready to spawn. These conclusions are based on limited tagging data, maturity schedules, and extrapolation from literature citations in which Dolly Varden have been shown to exhibit a strong degree of homing to their natal streams to spawn. Annual estimates of survival fit this pattern in that abundance of the partially immature age classes annually increases until full recruitment to the spawning population (age 5); then rapidly decline. The pattern of consistently declining estimates of survival from ages 5 to 8 also lend support to the hypothesis of annual return of spawning fish; survival would probably fluctuate if these fish were predominantly skip or sporadically spawning.

During 1991, there were more Dolly Varden counted at the weir by 15 August than in any previous year of weir operations and represents a two-fold increase in Dolly Varden abundance from 1990. Recruitment was either poor or mediocre through 1990 and this translated into decreases in abundance. Of particular concern is the 1990 spawning population. The fully recruited age classes to the spawning population were very poorly represented in a very weak return. Over one half of the total abundance for 1990 were age 4 or younger which are very poorly represented in the spawning population. The near term expectation for this stock is increased abundance as is evidenced by the improved recruitment of age-4 and -5 fish in 1991. It is unknown whether this near term increase in abundance will translate into a longer term increasing trend. Since historical harvests are still greater than even total abundance in 1991, an overall increase in abundance is warranted. Even moderate levels of fishing such as was sustained during 1990 is probably excessive in face of low abundance combined with low numbers of spawning fish present that year.

Examination of dynamic rates indicate that the Anchor River Dolly Varden stock has a high rate of turnover and to some extent, we should expect a high degree of fluctuation. Natural mortality is difficult to compute for most populations and is a critical parameter for many calculations. Several things can be gleaned from these data. First, the magnitude of the values indicates that these fish are fairly productive. In comparison, M for a population of anadromous Arctic char (*Salvelinus alpinus*) is only 0.17 (Moore 1975).

Second, the values of M are high in comparison to F (approximately an order of magnitude). This indicates that the number of deaths due to fishing is much lower than from "natural" causes. It should be noted that fishing mortality has been defined as that which takes place below the Anchor River weir in 1 year. If the fish are being harvested somewhere else, that will be reflected in these values of M. Also, all of these calculations are for age-6 to -8 fish and the literature is fairly emphatic that mortality due to spawning is high.

The effects from varying spawning escapements, documented since 1987, on recruitment will become evident over the next several years. The 1987 escapement will be providing age-4 Dolly Varden to the fishery during 1992. By continuing this project, the necessary data will be provided to further model the dynamic rates (survival, recruitment, mortality) of Anchor River Dolly Varden and determine if there is a relationship between the size of the spawning population and subsequent production. These estimates should be useful in developing appropriate regulatory measures.

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APPENDIX A

Equations for Point Estimates and Variances for the Creel Survey

The following equations were used to obtain catch and harvest estimates, along with their variances for each stratum. The catch and harvest were estimated for each sample period within a stratum, and estimated sample period mean catch (or harvest) was expanded over all sample periods in the stratum. The sample period catch (or harvest) was estimated by expanding estimated CPUE (or HPUE) by estimated effort (in angler-hours).

The first step in estimating the catch or harvest of Dolly Varden involved estimating the CPUE or HPUE for expansion purposes. In order to minimize bias in estimation of CPUE and HPUE a jackknife method was used (Efron 1982).

$\overset{*}{CPUE}_{hij}$ = the *jth* jackknifed estimate of CPUE;

$$= \frac{\sum_{\substack{k=1 \\ k \neq j}}^{m_{hi}} c_{hik}}{\sum_{\substack{k=1 \\ k \neq j}}^{m_{hi}} e_{hik}} \qquad [1]$$

where:

h = subscript denoting stratum;

i = subscript denoting day sampled;

j & k = subscripts denoting the angler interviewed;

m_{hi} = number of anglers interviewed during day *i* within stratum *h*;

c_{hik} = number of Dolly Varden caught by the *kth* angler interviewed during day *i* within stratum *h*; and

e_{hik} = number of hours fished by the *kth* angler interviewed during day *i* within stratum *h*.

Next, the mean jackknifed CPUE over all anglers interviewed in each sample was obtained:

$$\overline{\overset{*}{CPUE}}_{hi} = \frac{1}{m_{hi}} \sum_{j=1}^{m_{hi}} \overset{*}{CPUE}_{hij} \qquad [2]$$

A bias correction was performed (Efron 1982):

$$\overline{\overset{*\dagger}{CPUE}}_{hi} = m_{hi}(\overline{CPUE}_{hi} - \overline{\overset{*}{CPUE}}_{hi}) + \overline{\overset{*}{CPUE}}_{hi} \qquad [3]$$

where:

$\overline{CPUE}_{hi}$ = the "standard" mean CPUE (without jackknifing);

$$= \frac{\sum_{j=1}^{m_{hi}} c_{hij}}{\sum_{j=1}^{m_{hi}} e_{hij}} \quad [4]$$

Next, the bias-corrected mean jackknifed CPUE's were expanded by the estimated sample effort to obtain the estimated catch in each sample:

$$\hat{C}_{hi} = \hat{E}_{hi}\overline{CPUE}_{hi}^{*\dagger} \quad [5]$$

where:

$\hat{E}_{hi}$ = estimated angler effort expended by all anglers fishing during the *ith* sampled period, obtained as follows:

$$= H_{hi}\bar{x}_{hi} \quad [6]$$

where:

H_{hi} = number of hours during each day within sample unit *i*;

$\bar{x}_{hi}$ = mean angler count during the *ith* sample within stratum *h*;

$$= \frac{1}{r_{hi}} \sum_{o=1}^{r_{hi}} x_{hio} \quad [7]$$

where:

o = subscript denoting the count conducted within sample *i* and stratum *h*;

r_{hi} = number of angler counts conducted within sample *i* and stratum *h*; and

x_{hio} = the number of anglers counted (fishing) during count *o* within sample *i* and stratum *h*.

Then the mean estimated catch was obtained over all samples within stratum *h*:

$$\bar{\hat{C}} = \frac{1}{d_h} \sum_{i=1}^{d_h} \hat{C}_{hi} \quad [8]$$

where:

d_h = the number of days sampled (day = sampling unit) in stratum *h*.

The overall stratum catch estimate was then obtained by expanding for the number of days in each stratum:

$$\hat{C}_h = D_h \hat{\bar{C}}_h \quad [9]$$

where:

D_h = total number of days or sampling units in stratum *h*.

Finally, the total catch over all strata (or select combinations of strata) was obtained by summing the appropriate catch estimates:

$$\hat{C} = \sum_{h=1}^{L} \hat{C}h \quad [10]$$

where:

L = total number of strata in the fishery survey.

The estimated variance of catch for this stratified two-stage sampling design was obtained as follows (Cochran 1977):

$$\hat{V}[\hat{C}_h] = [(1 - f_{1h}) D_h^2 S_{1h}^2 / d_h] + [D_h \sum_{i=1}^{d_h} \hat{V}[C_{hi}] / d_h] \quad [11]$$

where:

f_{1h} = sampling fraction for days;

$$= d_h / D_h \; . \quad [12]$$

The variance equation for a systematic sample (Wolter 1985) was used to estimate the variance among days when the systematic sample design was successfully carried out;

$$S_{1h}^2 = \frac{\sum_{i=2}^{d_h} (\hat{C}_{hi} - \hat{C}_{h(i-1)})^2}{2(d_h - 1)} \; . \quad [13]$$

In some strata one or more sample days were not successfully sampled and the variance among days was estimated as follows:

$$S_{1h}^2 = \frac{\sum_{i=1}^{d_h} (\hat{C}_{hi} - \bar{C}_h)^2}{(d_h - 1)} \; . \quad [14]$$

The estimated variance of the sample estimate of catch is obtained by the formula for the variance of a product of random variables as proposed by Goodman (1960):

$$\hat{V}[\hat{C}_{hi}] = \hat{E}^2_{hi}\, s^{*2}_{2hi} + (\overline{CPUE}^{*\dagger}_{hi})^2\, \hat{V}[\hat{E}_{hi}] - s^{*2}_{2hi}\, \hat{V}[\hat{E}_{hi}] \qquad [15]$$

where s^{*2}_{2hi} is the jackknife estimate of the variance of the estimated sample CPUE as described by Efron (1982) and:

$$s^{*2}_{2hi} = \frac{(m_{hi} - 1)}{m_{hi}} \sum_{j=1}^{m_{hi}} (CPUE^{*}_{hij} - \overline{CPUE}^{*}_{hi})^2 \qquad [16]$$

the estimated variance of estimated sample angler effort is (Wolter 1985):

$$\hat{V}[\hat{E}_{hi}] = \frac{H_h^2}{r_{hi}} \frac{\sum_{o=2}^{r_{hi}} (x_{hio} - x_{hi(o-1)})^2}{2\,(r_{hi} - 1)} \; . \qquad [17]$$

The overall variance for all strata (or select combinations of strata) was obtained by summing the variances for each strata:

$$\hat{V}[\hat{C}] = \sum_{h=1}^{L} V[C_h] \; . \qquad [18]$$

Harvest estimates were obtained similarly by replacing the appropriate harvest statistics in place of the catch statistics in the above equations.

Effort and its variance were estimated by substituting the estimated mean sample effort (E_{hi}) in equations 9 to 13.

The assumptions of this estimator are:

1. CPUE and HPUE of interviewed anglers is representative of the CPUE and HPUE of all anglers during the sample period.

2. There is no significant fishing effort or catch taking place during times outside of the defined fishing day.

APPENDIX B

Fishery, physical, and biological data.

Appendix B1. Daily statistics for Anchor River Dolly Varden creel survey, 1991.

PERIOD[a]	DATE	Number of Interviews	Total Effort	Variance Effort	CPUE	Variance CPUE	Total Catch	Variance Catch	HPUE	Variance HPUE	Harvest	Variance Harvest
A	910703	1	19	139	0.0000	0.0000	0	0	0.0000	0.0000	0	0
A	910707	7	21	107	0.0000	0.0000	0	0	0.0000	0.0000	0	0
A	910711	1	8	48	0.0000	0.0000	0	0	0.0000	0.0000	0	0
A	910715	9	45	395	0.0000	0.0000	0	0	0.0000	0.0000	0	0
A	910719	6	99	283	0.3074	0.0563	30	559	0.1153	0.0037	11	39
A	910723	2	88	1067	1.2500	0.0625	110	2084	1.0000	0.0000	88	1067
A	910727	11	136	779	1.1170	0.2866	152	6049	0.3962	0.0239	54	546
A	910731	5	19	5	0.4723	0.1084	9	38	0.4010	0.0749	7	27
A	910804	17	107	1733	1.4526	0.2217	155	5795	0.2762	0.0045	29	176
A	910808	13	80	347	0.4020	0.0515	32	368	0.0345	0.0005	3	3
A	910812	19	112	1051	0.0000	0.0000	0	0	0.0000	0.0000	0	0
A	910816	14	227	11	0.0108	0.0001	2	6	0.0000	0.0000	0	0
A	910820	6	288	1563	0.0000	0.0000	0	0	0.0000	0.0000	0	0
A	910824	14	472	13467	0.0350	0.0004	17	104	0.0234	0.0003	11	68
A	910828	16	317	6299	0.0295	0.0005	9	52	0.0000	0.0000	0	0
A	910901	10	539	2357	0.1238	0.0095	67	2782	0.0825	0.0042	44	1236
B	910702	3	37	267	0.0000	0.0000	0	0	0.0000	0.0000	0	0
B	910705	1	61	219	0.0000	0.0000	0	0	0.0000	0.0000	0	0
B	910708	6	43	21	0.0000	0.0000	0	0	0.0000	0.0000	0	0
B	910711	5	29	11	0.0000	0.0000	0	0	0.0000	0.0000	0	0
B	910714	5	61	53	0.0526	0.0020	3	8	0.0526	0.0020	3	8
B	910717	10	144	283	0.2192	0.0164	32	348	0.1216	0.0080	18	168
B	910720	17	203	213	0.2078	0.0054	42	228	0.0658	0.0010	13	40
B	910726	28	264	1131	1.6189	0.2161	427	17778	0.1429	0.0011	38	100
B	910729	32	208	1627	0.7355	0.0378	153	2456	0.1754	0.0019	36	131
B	910801	16	35	181	0.1259	0.0066	4	10	0.0561	0.0016	2	2
B	910804	31	176	0	0.7130	0.0958	125	2969	0.0322	0.0003	6	9
B	910807	33	173	779	0.4722	0.0301	82	1053	0.0100	0.0001	2	3
B	910810	28	189	4677	0.2069	0.0042	39	331	0.0850	0.0019	16	92
B	910813	24	136	219	0.0609	0.0012	8	23	0.0305	0.0005	4	10
B	910816	3	171	565	0.0476	0.0069	8	200	0.0476	0.0069	8	200
B	910819	27	280	2075	0.0863	0.0021	24	177	0.0155	0.0002	4	17
B	910822	26	376	731	0.1151	0.0127	43	1796	0.0576	0.0032	22	449
B	910825	32	608	5568	0.0129	0.0001	8	32	0.0000	0.0000	0	0
B	910828	15	365	0	0.0000	0.0000	0	0	0.0000	0.0000	0	0
B	910831	21	691	6709	0.2523	0.0115	174	5854	0.0000	0.0000	0	0

[a] Period A = 0600 hours to 1359 hours and period B = 1400 hours to 2200 hours.

Appendix B2. Angler counts, by period, for the sport fishery on the Anchor River from 2 July through 1 September 1991.

	Period A (0600-1359 hours)						Period B (1400-2159 hours)					
	Count #1		Count # 2		Count # 3		Count # 1		Count # 2		Count # 3	
Date	Below Weir	Above Weir	Below Weir	Above Weir	Below Weir	Above Weir	Below Weir	Above Weir	Below Weir	Above Weir	Below Weir	Above Weir
702							1	2	0	2	6	3
703	0	0	0	1	3	3						
705							9	3	5	3	3	0
707	0	0	2	0	6	0						
708							6	0	5	1	4	0
711	0	0	0	0	2	1	3	1	3	0	4	0
714							2	6	7	2	6	0
715	0	0	5	0	12	0						
717							11	3	15	6	15	4
719	7	0	7	7	12	4						
720							23	7	20	4	15	7
723	4	1	5	2	15	6	16	7	10	2	10	9
726							23	2	38	1	34	1
727	8	0	17	2	24	0						
729							14	2	30	3	29	0
731	3	0	2	0	2	0						
801							4	0	5	2	0	2
804	4	0	19	2	14	1	21	1	15	7	16	6
807							18	4	21	6	14	2
808	15	0	5	2	7	1						
810							31	10	11	1	15	3
812	23	0	9	0	8	2						
813							18	0	13	1	19	0
816	28	0	28	1	28	0	14	1	20	0	25	4
819							34	0	42	2	26	1
820	27	2	27	4	44	4						
822							50	3	37	5	35	11
824	82	12	30	14	26	13						
825							42	36	72	18	46	14
828	37	27	26	4	19	6	16	10	13	25	51	22
831							27	33	68	25	61	45
901	46	21	30	28	47	30						

Appendix B3. Summary of completed angler responses to questions on the use of terminal tackle, residency, and fishing location, by date, 2 July-1 September 1991[a]. Anglers were targeting Dolly Varden.

	Terminal Tackle			Residency				Fishing Location	
Date	Bait	Lures	Both Bait and Lures	Resident	Non Resident	Local[b]	Non Local[c]	Downstream of Weir	Upstream of Weir
02-Jul	0	3	0	1	2	1	0	1	2
03-Jul	0	2	0	1	1	0	1	1	1
05-Jul	0	1	0	0	1	0	0	1	0
07-Jul	1	6	0	2	5	2	0	7	0
08-Jul	0	4	2	0	6	0	0	6	0
11-Jul	1	2	1	2	2	1	1	4	0
14-Jul	0	4	1	4	1	1	3	3	2
15-Jul	0	8	0	3	5	1	2	8	0
17-Jul	0	8	2	3	7	0	3	10	0
19-Jul	0	6	0	2	4	0	2	6	0
20-Jul	0	15	2	9	8	5	4	17	0
23-Jul	2	8	3	5	8	4	1	13	0
26-Jul	0	21	7	10	17	9	1	28	0
27-Jul	0	10	1	3	8	1	2	11	0
29-Jul	0	22	10	17	15	15	2	32	0
31-Jul	0	3	2	0	5	0	0	5	0
01-Aug	0	7	9	9	7	7	2	14	2
04-Aug	2	44	2	31	17	11	20	46	2
07-Aug	0	28	5	18	15	15	3	30	3
08-Jul	0	6	0	3	3	3	0	4	2
10-Jul	3	15	1	13	7	11	2	17	2
12-Jul	1	0	1	1	1	0	1	2	0
13-Jul	0	8	0	4	4	4	0	8	0
Total:	10	231	49	141	149	91	50	274	16

[a] Anglers did not target Dolly Varden after 13 August 1991.
[b] Resident angler living less than 35 km from Anchor Point.
[c] Resident angler living greater than 35 km from Anchor Point.

Appendix B4. Daily river water depth and temperature readings recorded at the Anchor River weir upstream trap, 1991.[a]

Date	Water Depth (cm)	Thermograph Reading HIGHS (Celsius)	LOWS (Celsius)	Difference (Celsius)
04-Jul	42.5	12.7		
05-Jul	45.0	12.6	11.3	1.3
06-Jul	47.5	11.8	10.2	1.6
07-Jul	72.5	11.3	10.0	1.3
08-Jul	62.5	12.6	9.2	3.4
09-Jul	50.0	14.7	10.5	4.2
10-Jul	48.8	13.1	11.2	1.9
11-Jul	57.5	12.2	10.7	1.5
12-Jul	52.5	11.4	10.0	1.4
13-Jul	47.5	12.7	10.0	2.7
14-Jul	45.0	14.3	9.8	4.5
15-Jul	42.5	14.0	11.2	2.8
16-Jul	42.5	12.8	10.1	2.7
17-Jul	43.8	14.1	10.1	4.0
18-Jul	42.5	13.4	10.0	3.4
19-Jul	40.0	13.9	10.1	3.8
20-Jul	40.0	16.0	10.9	5.1
21-Jul	38.8	17.0	10.4	6.6
22-Jul	38.8	15.0	11.6	3.4
23-Jul	37.5	13.7	11.6	2.1
24-Jul	38.8	13.5	10.1	3.4
25-Jul	37.5	16.5	10.6	5.9
26-Jul	36.3	16.9	10.4	6.5
27-Jul	36.3	17.6	11.5	6.1
28-Jul	36.3	15.4	12.0	3.4
29-Jul	35.0	14.2	11.8	2.4
30-Jul	35.6	13.0	10.5	2.5
31-Jul	45.0	11.7	10.5	1.2

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Appendix B4. (Page 2 of 2).

Date	Water Depth (cm)	Thermograph Reading HIGHS (Celsius)	LOWS (Celsius)	Difference (Celsius)
01-Aug	90.0	10.4	9.0	1.4
02-Aug	76.3	10.8	8.3	2.5
03-Aug	68.8	10.6	7.9	2.7
04-Aug	62.5	10.8	9.0	1.8
05-Aug	57.5	13.2	9.6	3.6
06-Aug	52.5	13.0	9.9	3.1
07-Aug	50.0	14.9	9.3	5.6
08-Aug	47.5	14.0	11.0	3.0
09-Aug	46.3			
10-Aug	45.0			
11-Aug	46.3			
12-Aug	46.3			
13-Aug	48.8			
14-Aug	48.8			

[a] Water temperature was recorded continually by thermograph while river depth was instantaneously recorded at 2200 hours daily. River water depth was relative to a selected location on the upstream trap.

Appendix B5. Number of fish, by species and date, passed upstream through the Anchor River weir during 1991.

Date	Species[a]						
	DV	SS	PS	KS	RS	CS	SH
04-Jul	1						
05-Jul	2		2	1			
06-Jul	5		16	1			
07-Jul	1		15				
08-Jul	0		2				
09-Jul	1		12		2		
10-Jul	6		46	2			
11-Jul	3		76		1		
12-Jul	2		25	1	1		
13-Jul	8		38				
14-Jul	3		17	1			
15-Jul	11		15		1		
16-Jul	10		9		1		
17-Jul	15		12	1		1	
18-Jul	73		26				
19-Jul	138		35		2		
20-Jul	298		18		1		
21-Jul	214		10	2	1		
22-Jul	351		40	1	1		
23-Jul	979		57	4			
24-Jul	985		35	1		2	
25-Jul	1,601		99	1	2		
26-Jul	1,780		192	3			
27-Jul	2,029		116		1		
28-Jul	1,485		81	2	1		
29-Jul	1,240		70				
30-Jul	1,438		54	1	1		
31-Jul	993		117	5	1	1	
01-Aug	1,554	1	109	3	8		
02-Aug	NO WEIR[b]						
03-Aug	NO WEIR						
04-Aug	165		9				
05-Aug	615		30	1	2	1	

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Appendix B5. (Page 2 of 2).

Date	Species[a] DV	SS	PS	KS	RS	CS	SH
06-Aug	561	1	46	1	2	3	
07-Aug	411	1	30		4		
08-Aug	281		29	1			1
09-Aug	263		36		3		
10-Aug	141	1	26	1	1	1	1
11-Aug	100	1	32	1	4		
12-Aug	77		31	3			3
13-Aug	67	3	60	1	4		0
14-Aug	77	5	65		1		
15-Aug	18		19				
Totals:	18,002	13	1,757	39	46	9	5

[a] Species: DV = Dolly Varden, SS = coho salmon, PS = pink salmon, KS = chinook salmon, RS = sockeye salmon, CS = chum salmon, SH = steelhead/rainbow trout

[b] High water levels in the Anchor River resulted in the removal of the rigid weir pickets from 1400 hours on 1 August through 1730 hours on 4 August.

Appendix B6. The daily and cumulative number of fish, by species, passed downstream through the Anchor River weir during 1991.

	Dolly Varden		Chinook S.		Pink Salmon		Sockeye S.		Coho Salmon	
DATE	Daily Count	Cum Count	Daily Count	Cum Count	Daily Count	Cum Count	Daily Count	Cum Count	Daily Count	Cum Count
04-Jul		0		0		0		0		0
05-Jul		0	2	2		0		0		0
06-Jul		0	4	6	2	2		0		0
07-Jul		0		6		2		0		0
08-Jul		0	1	7	1	3		0		0
09-Jul		0	2	9	1	4		0		0
10-Jul		0		9		4		0		0
11-Jul	2	2		9		4		0		0
12-Jul	1	3		9		4		0		0
13-Jul		3		9		4		0		0
14-Jul		3	2	11		4		0		0
15-Jul		3		11	2	6		0		0
16-Jul	1	4		11		6		0		0
17-Jul		4		11	3	9		0		0
18-Jul		4		11	5	14		0		0
19-Jul	1	5	1	12	7	21		0		0
20-Jul		5		12	2	23		0		0
21-Jul	1	6		12	3	26		0		0
22-Jul		6	1	13		26		0		0
23-Jul	1	7		13	3	29		0		0
24-Jul	3	10		13	3	32		0		0
25-Jul		10	1	14	8	40		0		0
26-Jul	1	11	2	16	6	46		0		0
27-Jul	2	13	1	17	6	52		0		0
28-Jul	1	14		17		52		0		0
29-Jul	3	17	2	19	1	53		0		0
30-Jul	12	29	2	21	1	54		0		0
31-Jul	14	43	5	26	9	63		0		0
01-Aug	1	44	7	33	11	74		0		0
02-Aug	NO WEIR	44		33		74		0		0
03-Aug	NO WEIR	44		33		74		0		0
04-Aug	1	45	3	36	9	83		0		0
05-Aug	6	51	3	39	35	118		0		0
06-Aug	7	58	2	41	43	161		0		0
07-Aug	16	74	1	42	41	202		0		0
08-Aug	16	90	2	44	41	243		0		0
09-Aug		90		44		243		0		0
10-Aug		90		44		243		0		0
11-Aug		90		44		243		0		0
12-Aug		90		44		243		0		0
13-Aug		90		44		243		0		0
14-Aug		90		44		243		0		0
15-Aug		90		44		243		0		0

Appendix B7. Daily summary of Dolly Varden age compositions from fish sampled at random from the upstream trap of the Anchor River weir, 1991.

Date	Age Group 2	3	4	5	6	7	8	9	Daily Total
07-Jul	0	2	6	1	0	0	0	0	9
10-Jul	0	0	0	2	1	1	1	0	5
24-Jul	0	8	21	8	1	1	0	0	39
25-Jul	1	1	18	28	11	6	3	0	68
06-Aug	1	14	35	45	18	4	1	1	119
Totals:	2	25	80	84	31	12	5	1	240

Appendix B8. Dolly Varden samples collected at random from the upstream trap of the Anchor River fish weir showing daily summaries of female gonad maturity and sex ratios, 1991.

Date	Female Maturity Index[a]					Sex Totals		Sample Size
	1	2	3	4	5	Females	Males	
07-Jul	3	0			0	3	6	9
10-Jul	0	4			1	5	0	5
24-Jul	15	2			4	21	18	39
25-Jul	9	22			8	39	29	68
06-Aug	25	40			12	77	43	120
TOTAL	52	68	0	0	25	145	96	241

[a] Maturity Index Codes:
1 = immature female with egg diameter less than 0.90 mm,
2 = mature female with egg diameter greater than 1.75 mm,
3 = completely mature female (eggs easily stripped),
4 = completely spawned female,
5 = immature female but shows development, egg diameter greater than 0.90 mm and less than 1.75 mm.

Appendix B9. Dolly Varden tag and recovery summary of fish tagged, by length of fish when tagged, in the Anchor River, Deep Creek, and Ninilchik River and recovered at least one season later, 1986-1991.

Tag Length (mm)	Tag Number	Date Tagged	Date Recovered	Recov. Length (mm)	Elapsed Days	Total Growth (mm)	Est. Yearly Growth (mm)	Location Tagged[a]	Location Recovered[a]	Subloc. Recovered[a]	Source of Recovery[b]
215	320	11-Aug-87	11-Jul-90	490	1065	275	94	ARW	ARW	UST	ADF&G
224	181	09-Aug-87	21-Jul-88	295	347	71	75	ARW	AR	UST	ADF&G
239	3441	08-Aug-87	16-Jul-88	303	343	64	68	ARW	NRW	UST	ADF&G
242	357	11-Aug-87	17-Jul-90	470	1071	228	78	ARW	ARW	UST	ADF&G
250	2843	02-Aug-87	16-Jul-88	404	349	154	161	ARW	AR	UST	ADF&G
251	360	11-Aug-87	11-Jul-90	480	1065	229	78	ARW	ARW	UST	ADF&G
256	4235	07-Sep-87	16-Jul-88	333	313	77	90	ARW	AR	UST	ADF&G
257	191	09-Aug-87	16-Jul-88	348	342	91	97	ARW	AR	UST	ADF&G
259	118790	17-Aug-89	06-Jul-90	-	323	-		ARW	KSR		Angler
271	460	14-Aug-87	20-Jul-88	370	341	99	106	ARW	AR	UST	ADF&G
271	117421	20-Jul-88	17-Jul-90	459	727	188	94	ARW	AR	SLIDE	Angler
278	993	22-Sep-87	27-Jul-89	444	674	166	90	NR	ARW	UST	ADF&G
295	118457	25-Jul-88	20-Jul-89	485	360	190	193	ARW	ARW	UST	ADF&G
298	117806	23-Jul-88	15-Jul-90	411	722	113	57	ARW	ARW	UST	ADF&G
300	1066	13-Jul-87	09-Jul-88	393	362	93	94	ARW	AR	UST	ADF&G
301	118221	28-Jul-88	30-Apr-89	306	276	5	7	ARW	SALT	H. SPIT	Angler
302	4087	25-Aug-87	26-Jul-88	392	336	90	98	ARW	AR	UST	ADF&G
306	116349	15-Jul-88	22-Apr-90	450	646	144	81	ARW	SALT	H. SPIT	Angler
307	116472	15-Jul-88	21-Jul-90	412	736	105	52	ARW	ARW	UST	Angler
314	813	09-Jul-88	21-Jul-89	404	377	90	87	ARW	ARW	UST	ADF&G
315	737	08-Jul-88	15-Jul-89	337	372	22	22	ARW	ARW	UST	ADF&G
315	852	09-Jul-88	23-Jul-89	405	379	90	87	ARW	ARW	UST	ADF&G
316	117715	22-Jul-88	30-Jul-89	430	373	114	112	ARW	ARW	UST	ADF&G
317	3467	08-Aug-87	09-Jul-88	403	336	86	93	ARW	AR	UST	ADF&G
317	117344	19-Jul-88	28-Jul-89	380	374	63	61	ARW	ARW	UST	ADF&G
318	116463	15-Jul-88	28-Jul-89	475	378	157	152	ARW	ARW	UST	ADF&G
319	829	09-Jul-88	12-Jul-89	410	368	91	90	ARW	ARW	UST	ADF&G
320	116049	12-Jul-88	18-Jul-89	330	371	10	10	ARW	ARW	UST	ADF&G
321	2071	25-Jul-87	18-Jul-88	398	359	77	78	ARW	AR	UST	ADF&G
324	117792	23-Jul-88	23-Jul-89	410	365	86	86	ARW	ARW	UST	ADF&G
325	3290	06-Aug-87	28-Jul-88	465	357	140	143	ARW	AR	UST	ADF&G
325	118192	27-Jul-88	28-Jul-89	421	366	96	96	ARW	ARW	UST	ADF&G
326	97	10-Jul-88	28-Jul-89	382	383	56	53	ARW	ARW	UST	ADF&G
326	117312	19-Jul-88	31-Jul-89	402	377	76	74	ARW	ARW	UST	ADF&G
327	1622	19-Jul-87	13-Jul-88	401	360	74	75	ARW	AR	UST	ADF&G
327	226	09-Aug-87	26-Jul-88	418	352	91	94	ARW	AR	UST	ADF&G
330	709	08-Jul-88	27-Apr-90	400	658	70	39	ARW	SALT	H. SPIT	Angler
330	116708	16-Jul-88	15-Jul-90	450	729	120	60	ARW	ARW	UST	ADF&G
337	118653	13-Aug-88	19-Jul-90	395	705	58	30	ARW	ARW	UST	ADF&G
338	117704	22-Jul-88	28-Jul-89	390	371	52	51	ARW	ARW	UST	ADF&G

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Appendix B9. (Page 2 of 3).

Tag Length (mm)	Tag Number	Date Tagged	Date Recovered	Recov. Length (mm)	Elapsed Days	Total Growth (mm)	Est. Yearly Growth (mm)	Location Tagged[a]	Location Recovered[a]	Subloc. Recovered[a]	Source of Recovery[b]
338	118162	27-Jul-88	20-Jul-90	460	723	122	62	ARW	ARW	UST	ADF&G
340	116053	12-Jul-88	13-Jul-90	474	731	134	67	ARW	ARW	UST	ADF&G
340	116125	12-Jul-88	26-Jul-89	435	379	95	91	ARW	ARW	UST	ADF&G
343	117533	20-Jul-88	18-Jul-89	415	363	72	72	ARW	ARW	UST	ADF&G
345	4114	27-Aug-87	09-Jul-88	387	317	42	48	ARW	AR	UST	ADF&G
345	799	10-Jul-88	24-Jul-89	440	379	95	91	ARW	ARW	UST	ADF&G
345	118380	29-Jul-88	31-Jul-89	414	367	69	69	ARW	ARW	UST	ADF&G
350	569	17-Aug-87	21-Jul-88	427	339	77	83	ARW	AR	UST	ADF&G
350	642	08-Jul-88	16-Jul-90	465	738	115	57	ARW	ARW	UST	ADF&G
350	763	09-Jul-88	01-May-90	400	661	50	28	ARW	SALT	H. SPIT	Angler
353	379	12-Aug-87	18-Jul-88	422	341	69	74	ARW	AR	UST	ADF&G
355	117155	18-Jul-88	26-Jul-89	438	373	83	81	ARW	ARW	UST	ADF&G
358	6990	20-Jul-87	15-Jul-88	550	361	192	194	DC	AR	UST	ADF&G
360	118328	29-Jul-88	04-Jul-90	460	705	100	52	ARW	SALT	PETERSON B.	COMM.
367	1084	13-Jul-87	19-Jul-88	473	372	106	104	ARW	AR	UST	ADF&G
367	116566	16-Jul-88	12-Jul-90	492	726	125	63	ARW	ARW	UST	ADF&G
370	118161	27-Jul-88	24-Jul-89	435	362	65	66	ARW	ARW	UST	ADF&G
387	117809	23-Jul-88	30-Jul-89	443	372	56	55	ARW	ARW	UST	ADF&G
390	280	10-Aug-87	22-Jul-88	448	347	58	61	ARW	AR	UST	ADF&G
390	631	08-Jul-88	15-Jul-90	545	737	155	77	ARW	ARW	UST	ADF&G
390	2	10-Jul-88	28-Jul-89	445	383	55	52	ARW	ARW	UST	ADF&G
390	116884	17-Jul-88	29-Jul-89	433	377	43	42	ARW	ARW	UST	ADF&G
390	117234	19-Jul-88	16-Jul-90	495	727	105	53	ARW	ARW	UST	ADF&G
390	117436	20-Jul-88	28-Jul-89	433	373	43	42	ARW	ARW	UST	ADF&G
398	118491	29-Jul-88	24-Jul-89	490	360	92	93	ARW	ARW	UST	ADF&G
399	4244	08-Sep-87	18-Jul-88	452	314	53	62	ARW	AR	UST	ADF&G
399	118354	29-Jul-88	16-Jul-90	484	717	85	43	ARW	ARW	UST	ADF&G
400	116261	14-Jul-88	27-Jul-89	575	378	175	169	ARW	ARW	UST	ADF&G
400	116437	15-Jul-88	27-Jul-89	457	377	57	55	ARW	ARW	UST	ADF&G
402	116610	16-Jul-88	20-Jul-89	425	369	23	23	ARW	ARW	UST	ADF&G
404	3141	05-Aug-87	18-Jul-88	458	348	54	57	ARW	AR	UST	ADF&G
410	943	24-Sep-87	17-Jul-88	450	297	40	49	NR	NRW	UST	ADF&G
411	1457	17-Jul-87	15-Jul-88	466	364	55	55	ARW	AR	UST	ADF&G
412	777	09-Jul-88	29-Jul-89	485	385	73	69	ARW	ARW	UST	ADF&G
415	116026	12-Jul-88	16-Jul-90	515	734	100	50	ARW	ARW	UST	ADF&G
418	117193	19-Jul-88	01-Aug-89	465	378	47	45	ARW	ARW	UST	ADF&G
421	459	11-Jul-88	29-Jul-89	443	383	22	21	ARW	ARW	UST	ADF&G
424	116290	15-Jul-88	28-Jul-89	475	378	51	49	ARW	ARW	UST	ADF&G
430	117622	21-Jul-88	27-Jul-89	480	371	50	49	ARW	ARW	UST	ADF&G
430	117622	21-Jul-88	30-Apr-91	500	1,013	70	23	ARW	SALT	H. SPIT	Angler
435	117310	19-Jul-88	20-Jul-89	505	366	70	70	ARW	ARW	UST	ADF&G
435	118253	28-Jul-88	13-Jul-90	496	715	61	31	ARW	ARW	UST	ADF&G

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Appendix B9. (Page 3 of 3).

Tag Length (mm)	Tag Number	Date Tagged	Date Recovered	Recov. Length (mm)	Elapsed Days	Total Growth (mm)	Est. Yearly Growth (mm)	Location Tagged[a]	Location Recovered[a]	Subloc. Recovered[a]	Source of Recovery[b]
435	116125	26-Jul-89	21-Jul-90	486	360	51	52	ARW	ARW	UST	ADF&G
450	116470	15-Jul-88	25-Jul-89	510	375	60	58	ARW	ARW	UST	ADF&G
451	118319	29-Jul-88	22-Jul-90	534	723	83	42	ARW	ARW	UST	ADF&G
455	116019	12-Jul-88	26-Jul-89	532	379	77	74	ARW	ARW	UST	ADF&G
469	118622	04-Aug-88	01-Aug-89	520	362	51	51	ARW	ARW	UST	ADF&G
475	116032	12-Jul-88	21-Jul-89	530	374	55	54	ARW	ARW	UST	ADF&G
476	116634	16-Jul-88	03-Aug-89	520	383	44	42	ARW	ARW	UST	ADF&G
480	117622	27-Jul-89	21-Jul-90	512	359	32	33	ARW	ARW	UST	ADF&G
515	1930	23-Jul-87	15-Jul-88	550	358	35	36	ARW	AR	UST	ADF&G
525	878	09-Jul-88	11-Jul-89	570	367	45	45	ARW	ARW	UST	ADF&G
532	116019	26-Jul-89	18-Jul-90	542	357	10	10	ARW	ARW	UST	ADF&G

[a] Locations:
AR = Anchor River
ARW = Anchor River Weir (RM 1.0)
DC = Deep Creek
H. SPIT = Homer Spit
KSR = Kasilof River
NR = Ninilchik River
NRW = Ninilchik River Weir
PETERSON B. = Peterson Bay
SALT = Salt water
SLIDE = Anchor River (RM 0.75)
UST = Upstream Trap (RM 1.0)

[b] Source: ADF&G = Alaska Department of Fish and Game
COMM. = Commercial fishery